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THE CONVERGENCE OF EVOLUTION AND FUNDAMENTALISM

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I

At the close of the first quarter of the twentieth century, it is interesting to compare the status of the theory of evolution with that at the beginning of the century. We even hear it asked whether the theory is solvent or insolvent. As for Darwinism, a separate account of its stock is being taken, with the fear that its solvency may be less than that of the general theory. A cursory survey of the situation seems to show that while the mere fact of evolution has become more and more evident as the years have gone by, nevertheless perplexities have continually multiplied. It has long been recognized that the causes of evolution are unknown, but it is only recently that we are beginning to realize that its method is in doubt and its significance not clear. Even the fitness of the word has lately been doubted, the strange question arising whether the changes and processes included by writers of the nineteenth century under the term "evolution" might be more aptly described by some other name.

Meanwhile biologists are not concerning themselves greatly with the theoretical problem but are entering upon a period of experimental work in genetics, which in respect to its patience and thoroughness compares with the memorable work of Darwin himself seventy-five years ago. In the years to come the puzzles of evolution will no doubt be solved, but at present we are much in the dark. The note of caution is the dominant note among those who are still writing on the theoretical problem. Post-war experiences have put a damper on the buoyant Spencerian optimism of the nineteenth century, while the recrudescence of the religious controversies has come as a kind of shock to those who had taken it for granted that these ancient differences had long been settled. It was truly a strange sight to those of us who recall the controversies of the latter part of the century to see at this late day scientists of the very highest rank entering the arena of the press to enumerate the evidences of evolution to a skeptical and impatient public. One wondered what had happened. A brief review will show what did happen.

When first the theory of evolution burst upon the world in the nineteenth century, it was the simple story of the continuity of plant and animal life. It was the story of the genetic relationship of plant and animal species, showing that all such species might have originated by descent from very simple forms of life. This innocent doctrine, long anticipated before Darwin's day, suddenly

assumed a tremendous importance and aroused an absorbing interest when Darwin marshaled his arguments to show that man—body, mind and morals—is to be included in this history. Then followed a violent controversy, since the new theory touched human traditions in a delicate spot, namely, in that of religious faith. At the close of the century, however, the Darwinian view, so far at least as it relates to animal species and the human body, prevailed. It was almost universally accepted by men of science. It had penetrated the literature of all cultured nations. It had settled down nearly to the lowest strata of popular thought. It had even reconciled itself with religious faith. The "ascent of man" from the lower forms of life was seen to add to his worth and dignity rather than to detract therefrom. It was believed that the religious attitude was greatly strengthened by the enlarged vision opened in evolution. Indeed a poet laureate sang:

> This is my loftiest greatness
> To have been born so low.
> Greater than Thou the ungrowing
> Am I that forever grow.

Straightway the notion of evolution was still further extended. We began to hear of inorganic evolution, cosmic, astral, geologic and atomic. Even the "delirious electrons" evolved into atoms, and matter itself was the product of a process of development. Social evolution had already made its appearance, and we learned that the new law applied also to the development of language, ideas, beliefs, the family, the church and the state, and to individual, social and political institutions. In fact, in those days of first enthusiasms, it occurred to no one that there is any realm of reality at all excluded from the field of evolution. Nothing is fixed or final; nothing is created; everything "just growed." Therewith was born a new and indeed fruitful and wonderful method of study, namely, the genetic method, which increased amazingly our understanding of things by revealing their genetic origins.

Then still another step was taken. Evolution was identified with progress.[1] A period of dizzy optimism followed. Every stage of evolution was "higher" and "better" than the preceding. Our path was "upward." Looking back we look "down." Just before the war human complacency knew no bounds. The industrial revolution had put us in possession of undreamed of power over nature. Time and space, water and air no longer imposed limits. Epidemic diseases could be overcome. Alcohol was to be abolished and crime thereby lessened. Votes for women were to purify our politics. Peace societies and arbitration treaties were to do away with war; and even when war was justified, it was in the same optimistic faith in progress through evolution, since the strong and cultured nations would through their warlike struggles demonstrate again the survival of the fittest. And, finally, it was thought that when human invention had been still further perfected and wealth still more heaped up, it would be necessary only to find some political device by which this wealth could be equally distributed—and behold a millennium.

Then came the crash. But the war was not the crash. For it was the war which was to end war and redeem the world for that ideal government called democracy. It was after the war that the trouble began. Neither states nor individuals behaved in that approved manner which we were led to expect. Rather there were national hatreds and suspicions and a sickening exhibition of individual avarice and greed. In Amer-

[1] In one sense purely physical evolution does include the element of progress. The subject is fully discussed by Lotka in his "Elements of Physical Biology," Chap. II. He defines evolution as "the history of a system undergoing irreversible change."

ica the bartender was banished, but the no less unsavory smuggler and bootlegger took his place. Crime was increased rather than lessened. A certain cultural refinement in manners and morals, gained through the ages with infinite labor, was suddenly lost. Women were coarsened, aping the men in their smoking and painting their faces after the manner of our savage ancestors. Indecency appeared on the stage and vulgarity on the pages of our popular fiction; and even the purity of the family, one of the foundation stones of a healthy social order, was violated by the increasing moral laxity and the ease and frequency of divorce. Almost over night, it seemed to the present writer, whose own memory of these cultural struggles extends back over fifty years, the bright faith in the future encouraged by the theory of evolution turned to fear and distrust. Books and articles suddenly appeared questioning the identity of evolution and progress, and questioning both progress and evolution. We heard all at once of the possible approach of a second dark age, of civilization at the crossroads and of the threatened collapse of our whole modern culture.

We can begin to understand, therefore, why it is that serious thinking people have turned a searching inquiry upon the whole theory of evolution itself. We can even understand why it is that a movement called "Fundamentalism" swept the country, invading our churches and our schools and even our legislatures, a movement in which the whole theory of evolution was questioned.

At first this fundamentalist movement seemed very incongruous. In a time like this it would appear that the fundamental things are honesty, temperance, purity and obedience to the laws of the state, rather than certain beliefs regarding the genealogy of man. To make a point of controversy of the latter seems like going rather far afield for trouble. Consequently, the suggestion has been made that fundamentalism was not due to any kind of religious intolerance but to a sort of dismay which serious and earnest religious workers felt in the presence of the threatened collapse of morals among our people, young and old. Something must be done. Let us fly back to both the faith and the moral virtues of our fathers.

Probably there is truth in this explanation of the fundamentalist movement. But perhaps the explanation is in part even simpler than this. Possibly it was to some extent a reaction against the superficial evolutionary optimism of the earlier years, together with a protest against a too careless and general application of Darwinism to every field of human thought and enterprise.

In part, also, it was a form of protest against certain materialistic and mechanistic interpretations of the doctrine, not shared by its original teachers and not necessarily involved in evolution at all, but rather noisily proclaimed by later disciples.

But at this stage of the agitation something else happened, adding weight to the fundamentalist's position. There appeared on the part of the evolutionists themselves a certain doubt and hesitation affecting some aspects of the theory, while certain utterances of distinguished biologists were interpreted as reflecting upon the theory. Really this doubt and hesitation did not involve the fact of evolution, the evidences for which had steadily increased, but they did apply to its causes and method, and particularly to the validity of that particular theory which goes by the name of "Darwinism." Thus it is easy to understand the new leverage which this gave to the party of opposition. It was possible to question the whole doctrine and to fall back upon the older theory of special creation, which was thought to have the support of religion and the Bible.

II

It may be worth while in the present article to review some of the limitations of the general theory of evolution as the twentieth century has revealed them and to inquire as to its real meaning. Incidentally, the inquiry may bring out some unexpected points of convergence between views which hitherto have seemed wholly contradictory. Such an inquiry will naturally limit itself to organic evolution, although a passing reference may be made to the question whether anything answering to the name *evolution* occurs in other fields.

Even in organic evolution an initial difficulty appears, and this is the question of the applicability of the word itself to the processes described. Literally the word *evolution* means an unrolling process, a process of unfolding, by which the implicit becomes explicit. Although Bateson in an address some years ago did actually propose such a theory, it was never taken very seriously by the scientific world, and perhaps was not intended to be so taken. Such a view would be attended by the blankest mystery. Evolution as it appears in the actual world is just the opposite of an unfolding process. Even the simplest Darwinian variation, much more a mutation, is a real increment, a novelty, a new creation, a veritable plus. I shall refer again presently to this all-important fact. Here it is sufficient to say that evolution is essentially an epigenetic, or building-up process, rather than an unfolding process.

Returning then to our discussion of the causes, manner and meaning of evolution, we may say at once that as regards its causes, they are unknown. It is only in the popular mind that the struggle for existence, heredity, variation and natural selection are regarded as the causes of the development of life. According to Darwin's hypothesis, if we grant the struggle for existence, that is, life and its insurgency, and if we grant heredity, and if we grant variation, why then we can understand the *manner* of evolution, because advantageous variations would be preserved by natural selection.

The anthropomorphic character of the word "selection" has now come to be well known. Selection implies discriminative appraisement. What we have in Darwinian evolution is the disappearance of unadaptive forms. There has also in recent years been a good deal of misunderstanding in the popular mind about heredity. Biologists who lecture on the Mendelian laws and the continuity of the germ plasm probably have no intention of claiming that these laws really explain the ultimate mystery of reproduction and heredity, but they are often so understood. The Mendelian laws, which have indeed completely revolutionized the study of genetics, reveal in a wonderful way the method of distribution of characters in the offspring, but of course do not explain why the offspring resembles the parent. Indeed, Mendel's laws, as Professor Caullery points out, actually embarrass us a good deal in the study of evolution, since they relate to the distribution and combination of factors already existing.[2] Likewise, it is only in the popular mind that Weismann's theory of the continuity of the germ plasm explains heredity. There is, of course, no actual continuity of the germ plasm from generation to generation, since the germ plasm is constantly increased, one codfish perhaps producing millions of eggs, and in this increase the whole mystery of heredity is involved. It is only the form that is actually continuous from generation to generation. The new form resembles the old. Heredity is resemblance. And so it is with variation and the struggle for existence. The causes of both are unknown. The struggle for existence is merely another

[2] See M. Caullery, "The Present State of the Problem of Evolution," Annual Report of the Smithsonian Institution, 1916, p. 332.

name for the insurgency of life, and life is insurgent because it is life.

Concerning the *manner* of evolution, we find at the close of the first quarter of our new century a disheartening uncertainty. It is just here that the last twenty-five years have seen the greatest change, and this change is manifest in the growing disappointment with the Darwinian selection theories. Keeping in mind that Darwinism is merely one of several theories as to the manner in which organic evolution has taken place, we must remember that the growing distrust of the Darwinian hypothesis does not indicate any distrust of the fact of evolution. Darwin's selection theories were most brilliant, ingenious and captivating. They completely won the scientific world, and a quarter of a century ago there were few who doubted their adequacy. In fact, we may say that there are few biologists to-day who would belittle Darwin's contribution or cast doubt upon the value of the theory of natural selection. But as a complete description of the method of evolution, it is very disappointing and as an explanation it sadly fails. That new species have arisen merely by the natural selection of small chance variations is a belief that is far weaker to-day than twenty-five years ago and appears to be steadily losing ground.

If, however, Darwin's selection theory still constituted a workable hypothesis, then our interest would be immediately transferred to the assumptions upon which the theory depends, namely, the struggle for existence, variation and heredity, none of which is understood. The latter fact does not, of course, in itself weaken the value of Darwin's theory, since the struggle for existence, variation and heredity are real facts. It only weakens the vast claims that have been made for Darwinism in explaining the present world of living beings, and it should be remembered that Darwin himself made no such vast claims. They are legends which have gradually grown up.

Since the valuable work of De Vries in the study of mutations, the mutation theory has to some extent supplanted Darwin's theory of small variations. Mutations are simply large variations. According to present-day biological nomenclature, all heritable variations are called mutations. The mere machinery of evolution remains the same as in the Darwinian plan. Mutations that are advantageous in the struggle for existence are preserved by natural selection. If, however, the mutation theory were used to explain the origin of species apart from the Darwinian theory, then the mutation theory could hardly be distinguished from so-called special creation. New species just appear. But if the mutations are simply to take the place of the original small chance variations, then the difficulty in explaining variations is intensified in the case of mutations. Darwin expressed great perplexity as to the cause of variations. What then would he say as to the cause of mutations? As regards the workableness of the mutation theory, it has some advantages over the theory of small variations, although difficulties enough remain. But as for explaining the present world of living beings, it stands just where the Darwinian theory stands, except that the embarrassment which Darwin felt about the cause of variations becomes amazement when we reflect upon the cause of mutations. On the whole, the mutation-selection theory as it stands at the present is a very doubtful explanation of the origin of species: that is, of the origin of the species that exist and have survived in nature.

Other theories of organic evolution than Darwin's are awakening interest today, but they have not passed out of the stage of speculation. Lamarck's theory commands new interest, as do the various orthogenetic theories. Lamarck introduced the important idea of the in-

fluence of desire and effort on the part of the organism in determining the direction of evolution. Here we have one of the causes of evolution clearly expressed. Lamarck's theory is not strictly a theory of evolution according to the exact meaning of the term, but it may be called a theory of development; while that of Darwin is neither evolution nor development. Evolution means unwrapping, the implicit becoming explicit. By development is meant the revelation of the successive phases of something in which there is a manifest unity.[3] It is the potential becoming actual. In Aristotle's metaphysics there is outlined a wonderful theory of the world that is distinctly developmental. Both Aristotle and Lamarck proposed theories of evolution which carried with them at the same time a kind of explanation of evolution, which Darwin's theory did not. A Lamarckian might indeed well adopt the Aristotelian view of the world as a great movement in the realization of ideal species and of higher values.

III

It appears, then, at the close of the first quarter of the century, that while the fact of evolution is not in doubt, the belief in it being firmer to-day than ever before, neither the causes of evolution nor the manner are known. Let us consider finally the *meaning* of evolution. Since neither the causes nor the method of evolution are known, evidently it means nothing more than that there are gradual changes in living forms in the direction of greater specialization and greater adaptation to the environment. Since such changes are going on before our eyes at the present time in plant and animal organisms and in the human mind and human affairs, there would not seem to be much ground for controversy here. To be sure, we should not put too much emphasis upon the word "gradual" in the above definition, since abrupt mutations are now emphasized more than the gradual small variations. It would seem necessary only to have the abrupt mutations abrupt enough, and the views of the evolutionists and of the special creationists would merge.

Since, then, evolution means nothing more than changes in plant and animal species in the direction of specialization and adaptation, it behooves us to ask concerning the meaning of these changes, and here another significant fact already referred to needs to be brought into the focus of attention. We have seen that the process of development is not an unrolling process, in which the implicit is merely becoming explicit. It is rather a building-up process in which something new is being constantly added. The whole movement should be called an epigenesis rather than an evolution. But the change in nomenclature can not be made, for the word *evolution* glides from the tongue with astonishing ease, involving, as some one has said, like the corresponding German word *Entwickelung,* all the elements of our vocal apparatus in a most harmonious manner, while the word "epigenesis" is harsh and forbidding. Furthermore, the word epigenesis in biology has a technical meaning debarring it from general use.

To be sure, the claim might be made, and indeed has been made, that the whole evolutionary process *is* one of unfolding, a kind of unwrapping, all later forms of life being present potentially in the amoeba; but the only possible argument for this view would be that since everything has come out of the original simple forms of life, everything must have been potentially present in them. But perhaps everything has not come out of these simple living forms. This is a pure assumption. Possibly something has been added all the way along.

[3] A logical analysis of the concept of evolution and of development will be found in "The Concept of Evolution," by H. W. B. Joseph, Oxford, 1924.

We speak of the evolution of the automobile, but the latest skilled product of the automobile art was not potential in the first crude machine. Every improvement has been a new creation. Suppose that you are building a new house and you describe how the plan has "evolved" in your mind. But the fact is that every change or every addition was a new thought, an improvement, a plus, a creation. The original simple house plan did not contain any potency of the final perfected scheme.

Briefly, then, the meaning of evolution is that it is a creative process, something new appearing at every step of the developmental history. Evolution is a process not of unrolling but of upbuilding. Every change is a transformation. The French word *transformisme* is a happier word than the English "evolution" or the German *Entwickelung*.

Evolution is a history of new forms and functions. Every new form is a plus—a new creation. Since Wundt introduced the notion of creative synthesis, the word *creation* is coming into general use both in science and philosophy. Creative evolution is a phrase made famous by Bergson. Professor Moore in his book, "The Origin and Nature of Life," says that "traces of evidences are lately beginning to come into view which are highly suggestive of continuous present-day creation of matter at the inorganic level, and of creation of life from inorganic materials at the organic level." Creation does not mean the production of something out of nothing. The architect creates a Gothic cathedral, but he does not create the stone and mortar. The promoter creates a new organization, but he does not create the men that compose it. Creation means just this—the production of something distinctly new and unique. Reality is found, as Aristotle told us long ago, in structure, form, organization and function, not in the mere stuff which happens to compose the material. Organic evolution is essentially constructive and creative.

IV

Out of all this there emerges a curious and unexpected convergence of the two supposedly irreconcilable theories of the evolutionist and the special creationist. An illustration will make this convergence clearer. It is repugnant to the special creationists to suppose that the mind of man has been evolved from animal behavior. But we see now that mind according to the evolutionists is not something evolved *out of* animal behavior. Mind is in no way potential in such behavior. When it comes it is something new. Even according to the obsolescent Darwinian theory of small variations, every variation is a novelty, and somewhere in the history of mental development an all-wise observer would be obliged to say, "This is no longer animal instinct, it is mind"; while according to the mutation theory, we may believe that mind more suddenly appeared.

Let us suppose, however, that the special creationist is not satisfied with this identification of the two views. He believes that God created man in his own image a little lower than the angels, while evolution teaches that man is descended from ape-like creatures by a natural process. The two views are thus, as he thinks, diametrically opposed. But are they opposed at all? A little careful reflection will show that they are very much alike, for whence, according to the theory of evolution, come those all-important variations, those wonderful and unexplained mutations, those significant increments and novelties? They just appear. But they do not appear without a cause and, as we have seen, they are not implicit in the first life germs. If, however, as evolutionists believe, they are upward steps in an epigenetic process, if they are new creations, some adequate creative power seems to be implied. As life and mind are the results of the organization of simple physical and mechanical units, some adequate organizing agency is required. Something or some one is mar-

shaling the units into a majestic order, call it, if you please, with Wells and Shaw, a life force; call it with Bergson an *élan vital;* call it an evolutionary urge, or struggle for existence, or will to live; or call it, as Lloyd Morgan does in his recent book on Emergent Evolution, just simply God.

Here, of course, the objection may be urged that the reconciliation is very incomplete, since the evolutionist often does not admit the existence of any life force, or *élan vital,* or any creative God, but attributes the whole evolutionary movement to the action of resident forces. Le Conte, for instance, defined evolution as continuous progressive change according to certain laws and by means of resident forces. But the fundamentalist might have no objection to this definition, for he, no doubt, believes in an *immanent* God, who "resides" in the world and exercises his creative power there; and the evolutionists, at least many twentieth century evolutionists, when they speak of resident forces do not use the word *force* in the sense which it bears in the mechanical sciences, for the latter is not cumulative, creative nor progressive. In like manner the old dispute as to whether the creative forces are natural or supernatural has lost its significance, since the meaning of the word *supernatural* depends wholly on the limitation which one chooses to put on the term *nature* or *natural.*

But what about the other part of the fundamentalist's creed, namely, that "man was created in the image of God, a little lower than the angels"? At first it seems as if there were a fearful contrast between this view and the doctrine that man is descended from ape-like creatures, but the contrast speedily disappears when we reflect that man by means of these successive increments has progressed so far away from the ape-like creatures that he is now only a little lower than the angels. According to the evolutionary theory of the present, it is a very long time that man has lived upon the earth, half a million years and perhaps much more. If one should go back farther than that remote time and inquire as to the form of the prehuman race, it could only be said that such a race was neither simian nor human. But the significant fact is that in that immense time man has climbed a long way toward the angels and seems indeed to be approaching the image of God. For we think of God as the power which makes for righteousness, the sum of ideal values. and slowly but surely, now with rapid steps, now slipping a little back, man is realizing those ideal values. He is never satisfied with the heights he has gained, but aspires upward. Human slavery, war, the subjection of woman, child labor, religious intolerance, intemperance—they were all once just taken for granted. Now we are ashamed of them all. Some are gone, all will have to go. Human interests are ever getting higher. Art, literature, science, philosophy, social service, social justice, more equal opportunities, rights of women, of children and of laborers—these are the enterprises of men of the twentieth century.

Another feature of twentieth century evolution is the lesser emphasis put upon the notion of nature as a battlefield—as a scene of sanguinary and ruthless struggle in which the fittest survive. This was one of the unhappy ideas associated with the name of Darwin, even until recently made the excuse and vindication of every evil thing in human society. It is unfortunate that a part of this precious twentieth century has got to be spent in "unthinking our convenient Darwinism." Professor Patten, writing as a biologist, says that the altruism and cooperation which we are coming to recognize as the absolutely indispensable condition of further social evolution are basal and primary factors in the grand strategy of evolution in nature itself.

In fact, there seem to be indications

that the whole evolutionary nomenclature of the nineteenth century was unfortunate. Perhaps we need a new set of terms all around to describe that great world movement which for seventy-five years has gone by the name of *evolution*. Many biologists are beginning to question the presupposition of the nineteenth century that the concepts of the mechanical sciences have any special prerogative in the interpretation of life and mind and society. Professor Haldane has gone so far as to reverse the order and suggests that "the idea of life is nearer to reality than the idea of matter and energy," and J. Arthur Thomson believes that the formulae of physics and chemistry are no longer adequate for the description of behavior or of development or of evolution. It is generally felt that Herbert Spencer "put something over" on the scientific world when he exalted a certain trio of concepts, namely, matter, motion and force, whose redistribution was to explain the whole world.

Biologists of the present time are largely engaged in patient and persistent investigation in the field of genetics, wisely refraining from speculation as to the causes and meaning of evolution. But it is difficult to refrain from all speculation, and when biologists do enter the field of philosophy and speak of theories of evolution, it is interesting to notice the new terms which they are using. We hear much of creative evolution, not always in the strict Bergsonian sense. We hear of "emergent evolution."[4] We hear evolution described as "a struggle for freedom,"[5] or as a process in "self-expression." We hear of animate nature as being the work of "an artist with inexhaustible imaginative resources, with extraordinary mastery of materials."[6] We hear of the material fabric of nature as being "alert" rather than "inert." We hear of "the grand strategy of evolution."[7] We even hear of evolution as a process of achievement, in which life and mind and moral conduct and social organization and science and art are values which have been won.

V

It should be noticed finally that the insufficiency of the terminology of evolution has been shown equally in other fields of inquiry than in the plant and animal kingdoms. When we hear of astral, geological, atomic and societal evolution, we wonder just what content the word carries in these several fields. Herbert Spencer, to be sure, devised a celebrated formula which he called evolution and which he thought he could spread like a net over the operations of nature in every phase of its activity. Evolution, he said, is "an integration of matter and concomitant dissipation of motion; during which the matter passes from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity; and during which the retained motion undergoes a parallel transformation." In the last century this was considered a brilliant generalization, explaining the meaning of evolution. It is now considered a rather empty formula, significant and interesting, to be sure, and true in a way, but not so universal or significant as Spencer thought. Certainly it has no claim to being a law of nature, since one would hesitate to use it in predicting the future in any field of inquiry. With our fuller knowledge now, I think we should say of Spencer's formula—If it be true, what of it? We may call this evolution, but we are no wiser than before. Spencer's identification of evolution with progress, furthermore, no longer commands respect.

[4] Compare C. Lloyd Morgan, "Emergent Evolution," and J. Arthur Thomson, "Concerning Evolution," p. 205.

[5] By Albert P. Mathews in "The Road of Evolution," *Yale Review*, January, 1922.

[6] "The Outline of Science," Vol. iii, p. 705.

[7] Compare William Patten, "The Grand Strategy of Evolution."

What content has the word *evolution* as applied to society? Recent schools of sociologists place much less emphasis than formerly upon the concept of societal evolution, and when they use the word they mean usually nothing more than that society changes in a certain orderly manner. Society does not unroll, neither are its movements well described by Spencer's formula. Society changes, and as we look back upon these changes we can detect a certain "design," not of course in the sense of something designed, but of something in which a certain unity and meaning can be discerned. When, therefore, sociologists persist in speaking of social evolution, it is rather from the force of habit or the tyranny of nineteenth century thought than from any special appropriateness of the word. Society does not unroll nor evolve; it is changed, enlarged, and *sometimes* perfected by the successive additions of new ideas and institutions, such for instance as the cinema, the automobile, aerial transportation, votes for women, the League of Nations, limitation of armaments.

One hears again of mental evolution, but if from our modern point of view we examine the process by which mind has come into the world of living organisms, we find that the word evolution fits it poorly. There is no evidence, for instance, that those fundamental elements of mind which we call conative tendencies, wishes, impulses, those profound "energy influences seething and bubbling in the organism" *evolve* in any sense of the word. They seem rather like persisting appetites or cravings or aspirations seeking a goal. Neither does intelligence nor consciousness evolve. Instincts are not potential in tropisms nor is adaptive behavior potential in instinct, nor is intelligence a more complex form of instinct. Intelligence, when it comes, is something new—a new instrument, a novelty, perhaps an achievement. The mechanistic, Spencerian, Darwinian vocabulary of the nineteenth century does not fit the birth of mind, nor do the formulae of evolution illumine it. And then, of course, there are great spheres of reality where evolution is not present in any sense, such for instance as time and space and the laws of logic and mathematics and the laws of nature.

One hears also lately much about the evolution of matter. What does the word mean here? The discovery has been made that the atoms of certain elements of high atomic weight disintegrate into elements of lower atomic weight. The guess is ventured, therefore, that all the elements may be theoretically resolvable into a simple element, such as hydrogen, and the further guess is ventured that somewhere and sometime the reverse process may take place, so that from some simple element, such as hydrogen, all the other elements may arise, and presumably they will arise in the order of their atomic weight. To the latter process the name evolution has been applied. But it seems to be just the opposite of an evolutionary or unrolling process. It seems much more like a creative synthesis, an architectural enterprise. One looks instinctively for the architect.

In fact, not only in the creation of matter and in the birth of mind, but throughout the whole course of nature's expansion, the thought of the twentieth century seems to dwell on other aspects than those emphasized by Spencer and Darwin. Our interest is now centered more upon "formative forces," forces that are creative, cumulative and synthetic. "Organization" is a better word than "evolution." The new does not come from the old either by a process of unrolling or by a mere additive process. It appears to come as a result of organization. Even the word "organization" seems too tame as a description of Nature's efforts. As Stewart Ed-

ward White says in his recent book "Credo," nature seems to be the upsurging of a single vitality seeking outlet, and Bernard Shaw thinks that the saying, "Where there is a will there is a way" expresses more truly the meaning of evolution than the Darwinian selection theories.

In the eventful years which are to follow in this wonderful twentieth century, when the future of our civilization seems to be in the balance, the two things that are most needed are cooperation and creative effort. And strangely enough, the science of the day finds just these two things to be principles more original and significant than the chance variation and survival of the fittest which characterized nineteenth century thought.

There is no real reason to believe that the forces which are working towards progress in society to-day are essentially different from the forces which in the past have been productive of every new step in the development of plant and animal life or in the production of animal and human intelligence or of consciousness and moral judgment. The phrase "creative effort" designates these forces better than the term evolution. It remains for some one to discover a still apter term to characterize the world movement, a term which shall catch the ear of the twentieth century as evolution did in the century past. When this new term is discovered, evolutionists and fundamentalists may find some of their differences harmonized.

OVER-POPULATION AND THE LIVING-STANDARD

By Professor EZRA BOWEN
LAFAYETTE COLLEGE

A TINY colony of ants appears upon your hearth. A few grains of sugar somehow fell there and attracted these immigrants. There was food in the region from which they came, but it was not so plentiful as in this New World. Just so has America become peopled with Europeans.

An ant, let us say, requires for sustenance one grain of sugar a day; you supply, daily, exactly ten grains; the ant population will soon settle down to exactly ten. If there were originally thirteen ants, three must emigrate or die. There are just ten grains of sugar, and that will support ten ants—no more.[1] The rate of propagation is a furious one. That matters not. Ants in other regions get wind of the sugar, and a terrific immigration sets in. Again, no matter. Immigration, emigration, death-rates, even birth-rates, have nothing to do with population; or rather, they are secondary matters, themselves determined ultimately by economic considerations. The controlling fact is the sugar supply, ten grains; that settles it, a population of ten, yesterday, to-day, forever. . . . The population of Nevada per square mile amounts to seven tenths of a person; Nevada's meagerness will support no more. But Massachusetts' humming mill-wheels produce a flow of value that supports a population, per square mile, of four hundred and seventy-nine. More sugar, more ants.

In a burst of open-handedness, you raise the sugar ration to twenty grains. A few weeks later you take a census—and with what result? To be sure: twenty ants. There was immigration, but no matter; the death-rate slackened; even the birth-rate may have changed—we must ask the biologist about that—but no matter. There is but one matter of import: twenty grains of sugar, daily, instead of ten. Ten grains: ten ants. Twenty grains: twenty ants.

For hundreds of generations, the population of North America (before Columbus) remained nearly stationary at a million and a half: to-day, only four and a half centuries later, it is a hundred times as great. The vast wilderness for thousands of years yielded to bow and arrow sustenance enough for a million and a half of mankind—no more. Then forests were felled, making rich tillage and pasturage. Machinery came, and system, and science, opening richer fields: coal fields, oil fields, iron fields, copper fields, gold fields. A Niagara of value poured forth its abundance. Population increased a hundred-fold. More grains of sugar: more ants.

Let us see how our little colony is getting on: Twenty grains of sugar, daily, and twenty ants. . . . However absurd, let us say our ants demand some bird-shot to roll about in play. No; our generosity will not afford so much. But as they insist—especially two or three fat fellows that nibble some other's sugar grain when theirs is eaten—we

[1] This ant example is of course purely imaginary, a mechanical or artificial illustration. The physicist, exhibiting the model of an oxygen atom, is not trying to prove a theory of matter, but merely endeavoring to *illustrate* a strongly appealing hypothesis. In fact, this little essay is, in whole, simply an attempt to illustrate an hypothesis of population—a clearer and fuller statement of the author's "Sponge Theory of Population," published in the January 7, 1925, issue of *The New Republic.*

compromise on ten shot and, daily, ten grains of sugar. Ten grains of sugar and twenty ants? Yes; ten ants must die. A standard of living that includes both sustenance and play pinches out ten lives. High and unbalanced living-standards are as deadly as natural scarcities.

Had our ants been content with five shot for play and fifteen grains of sugar, the population could have been maintained at fifteen. Had they insisted upon their shot and other gimcracks besides, driving us to cut the ration to five sugar grains, the surviving ants would have lived a well-equipped, civilized, sophisticated life; but the survivors would number only five. . . . Our example is absurd?—it is not true to ant life? No; but true of man life, where interest is thus divided between desires and needs.

A wren, a mouse, a perch—all living things but man—have a fixed standard of living, a bellyful every so often, and nothing further. An increase in sustenance means a like increase in population. But man produces consciously a large part of the food values he consumes, and he insists upon producing and consuming other values as well. (The value of the motor-car that just flashed by —that value, in food, would support a workman's family for seven years.) Man's productive energy is divided; part is expended upon the production of food values, and part upon the production of far different values: buildings and clothes, steamships and railways, theaters and parks, telephones and motion pictures, radios and motor-cars, smoking materials and chewing gum. In the proportion that these things enter into the living standard by just so much, the tendency of human population to increase as wealth increases is thwarted. Populations, whether of ants or wolves or butterflies or men, tend to increase directly as weal increases; but when we speak particularly of man, we must add: population tends to decrease as the standard of living rises.

Though the flow of wealth in Great Britain more than equals that of China, the population of Great Britain is but forty million, and the population of China four hundred million. A vast difference in living standards explains this striking contrast: the Chinese standard of living is hardly a tenth as high as the British. The population of the United States is one hundred and ten million; the population of India triples that amount, though India's rate of wealth production is not a third that of the United States. Again, a difference in living standards will explain. If Americans were to convert into food the huge flow of value they create, contenting themselves with an East Indian standard of living, the population would soon number half a billion—assuming, of course, the necessary improvement in agriculture, or the production of synthetic foods; and neither of these assumptions is so bold as the suggestion that the American cut his standard to a tenth its present dizzy height.

Birth-rates, death-rates, immigration, emigration—all are secondary considerations in the population problem. The piston, piston-rod and crank-shaft of an engine are important, but secondary, circumstances; the underlying matter is the expansive force of steam. Controlling factors in the growth of human populations are but two: the rate of wealth production and the standard of living.

Insect, animal, reptile and plant populations vary directly as the means to existence increase or decrease. These creatures are not hampered by intelligence and a craving for ever higher living standards. But with man it is different: *As between areas in which similar standards of living prevail, population varies according to the amount of annually available wealth; in areas that produce equal amounts of wealth, popu-*

lation varies inversely with the height of living-standards.

The amount of value produced annually in Montana is about equalled in Mississippi: but Mississippi has three times Montana's population. Simply, the standard of living in the Southern black belt is very low. Standards of living, on the other hand, are about the same in Idaho and Kansas; yet Kansas' population is four times that of Idaho. And why? Kansas produces annually a far greater wealth than does Idaho. If the flow of value in Great Britain increases ten per cent., but every family consumes ten per cent. more, in comforts or in luxuries, population must remain the same.

One more principle must be included to cover fully the man case in population: Standards of living tend to increase more rapidly than wealth. Everyone sees this principle at work in his neighbor's conduct—some few admit its influence upon themselves. Give the brilliant young thirty-six-hundred-dollar-a-year assistant-cashier of a big city bank a vice-presidency, and how quickly his standard of living runs up to and exhausts his new twenty thousand dollars. The laborer, with his large family, has a milder craving for a high plane of material existence than has the foreman over him. The penniless negro has less concern over the growth of his family than has his well-to-do white neighbor; the mechanic minds less his increasing brood than does the rising young physician—his worried eye flitting from wife to calendar to bank-book. If standards of living increased proportionately with wealth, the tendency toward small families would be the same all down the line; but as you run the economic scale, you find, as wealth increases, the pressure toward restriction becoming ever greater—this, as true of nations as of families. For standards of living—or of craving—increase *more rapidly than* wealth. Wants increase as wealth increases, and this is generally recognized; but, quite as important and nowhere recognized, is the fact that this increase itself increases—there is acceleration. Here is a principle that goes far in explaining the large families of the poor, and why the tendency toward restriction works in the well-to-do family and in the prosperous nation with such devastating effect.

Populations of all kinds, animal and vegetable, tend to increase directly with abundance in the means of existence. With man, the consumer of varied and conflicting values, population tends to increase as the flow of value rises, but this tendency is offset to the extent that non-essential values enter into the rising living standard. We have no quarrel with modern standards of living; to the contrary, higher and higher standards are desirable, and as inevitable as they are good. An explanation of the principles of population is all that is here attempted. But if a moral must be pointed, it is this: The desirability of a good quality of food and other essentials is by its very obviousness thrust into some oubliette of consciousness; while luxuries, which are the more conspicuous for their scarcity, are feverishly desired. Until education has given every one a much sounder scale of values, some external influence must be set up to make the emphasis in the consumption of goods and services fall where it should.

The upward trend of living standards, almost entirely the result of an increasing insistence upon nonessentials, constantly outruns all gains in wealth. Presuming no change in man's scale of values, our net conclusion then must be: The enigmatic, decreasing increase, at present so conspicuously general to human populations, will continue—until of course, populations begin actually to shrink.

LESSONS FROM FIJI

By Professor C. C. NUTTING

UNIVERSITY OF IOWA

I

Our friends received the news that we were going to Fiji with cheerful predictions that we would meet our fate as interior decorations of the natives. This typifies the ordinary information that most Americans are conscious of regarding Fijians—that they are cannibals; and it is just about as up-to-date as a belief that Americans are given over to the practice of burning witches.

A hasty review of recent publications regarding the South Seas gives one the impression that few of us go there with the idea of learning anything that is of ethical importance or soul-elevating. Some go to exploit the simple savage in a commercial way, others to teach him to be good and civilized; and still others, and they reap a rich literary harvest, to expatiate on a paradise of lovely women in scant raiment and morals to match.

Our party of naturalists from the State University of Iowa had no such objectives. We hoped to learn a few worth-while things, and we did; indeed, we learned so much that was unexpected that we are garrulous about it. The natives themselves interested us most of all. The population of the Fiji group furnishes material for serious reflection, particularly to one who has the point of view of the professional biologist; a way of looking at things that is not evident in recent publications concerning the South Seas, but never the less well worth presentation and consideration. There are about ninety thousand Fijians proper, sixty-one thousand "Indians" or Hindus, as we would call them, and forty-five hundred whites scattered through the two hundred islands, most of which are small and uninhabited. The total area is somewhat greater than that of the British West Indies, excluding Trinidad.

We found the Fijians as different from the other Polynesians to the eastward as the English are from the French. They are upstanding, soldierly fellows, not flabby, but with good hard muscles; men who looked the white man in the eye without either servility or truculence, men who dealt honestly with you and insisted on honest dealing in return. They are considerably darker than the other Polynesians that we saw, probably owing to a negroid admixture from New Guinea or New Hebrides, and seem to be more alert and virile than the natives of Rarotonga and Tahiti, for instance. Their chief personal adornment is their hair, in which some of them take inordinate pride. It is kinky, but not woolly, stands out for four or five inches all around the head like a black or reddish-black halo, and is clipped evenly as by a lawn-mower; really an imposing and stately head ornament.

One man, belonging to the Defense Force and sporting a particularly fine *coiffure*, explained that he washed his hair thoroughly three times a day, dried it carefully, rubbed in cocoanut oil and then combed it out straight. He slept with a stick of wood under his neck, so that the precious headdress should not touch the ground. This seems a lot of trouble, but these men evidently think it worth it and it costs nothing but time.

I doubt that history can show a greater or more rapid change for the better than has taken place in Fiji during the last two or three generations. The details of the life and customs of these people given in the narrative of the Wilkes

A MILITARY DANDY OF FIJI, INORDINATELY PROUD OF HIS HAIR.

Expedition near the middle of the last century are so revolting as to be scarcely credible. Constant wars, pillage, murder, massacres of whole communities, cannibalism and other atrocities too frightful for detailed description fill many chapters devoted to Viti Levu, the main island; and these conditions prevailed up to within the memory of men now living, one of whom I saw at Bau.

II

Compare the nightmare of the last century with the situation as we found it. A people kindly, courteous, law-abiding, with no experience with tribal war for many years; a people among whom a stranger can travel in security. As a proof of the absence of thievery, for instance, it is sufficient to cite the fact that the Fiji Club, where we were given quarters while in Suva, has its doors and windows perpetually open day and night, even when the lights are out and all hands are asleep. Yet not a thing was stolen and no one seemed to consider even the possibility of theft. I was told by Colonial Secretary Fell that a stranger could visit even the remotest parts of Viti Levu with perfect safety to life and property. The natives are uniformly hospitable, even in the jungles of the interior; although it may be somewhat embarrassing to have the entire population of a village insist on seeing one to bed!

No one can contrast the past with the present conditions in Fiji without seeking the cause of this amazing transformation, and any honest inquiry will show that two factors are in the main responsible. One of these is the work of the missions and the other the wise colonial policy of Great Britain.

RATU POPÉ, CHIEF OF BAU, GRANDSON OF THE LAST FIJI KING.

One of the most popular pastimes of travelers in the South Seas is "knocking the missionaries," a sport hugely enjoyed by the very men whose lives would be an exceedingly bad insurance risk were it not for the presence and teaching of these same missionaries. The colonial authorities, who presumably know what they are talking about, have little sympathy with this form of diversion; but, on the contrary, are warm in their appreciation of the results attained by the various missions, be they Wesleyan, Roman Catholic or of any other denomination.

On invitation I accompanied the superintendent of schools on a trip to inspect the Wesleyan Mission in charge of the Reverend Donald Lelean. It occupies a large tract of high rolling land overlooking the Rewa River. The Baker Memorial School is one of the best buildings we saw in Fiji, and the entire plant indicates thrift, industry and good management. The station has a population of about five hundred people, including Fijians, Indians and missionaries, together with their families; and they raise enough taro, yams, bananas and other vegetables to meet their entire needs. Here is the first kindergarten established in Fiji, and a manual training school where natives under the direction of skilled mechanics make furniture and other things, some of them under contract with the government. Their grandfathers were cannibals during the bloody régime of Cacobau, the last of the Fiji kings and grandfather of my host, Ratu Popé of Bau.

Our investigation of the situation in Fiji gives us the feeling that knocking the missionaries would be just about as zestful an amusement as abusing the lassies of the Salvation Army; and I confess to a suspicion that some recent trav-

A FIJIAN COSTUME, NOT OF FIG LEAVES.

elers to the South Seas feel a personal resentment against the missionaries for their activity in blocking the unrestrained enjoyment of the unmoral condition of the childlike natives.

It is hard to resist the further impression that there is a similar background for the indignation aroused by the insistence on the part of the missionaries that the natives wear at least a decent minimum of clothes.

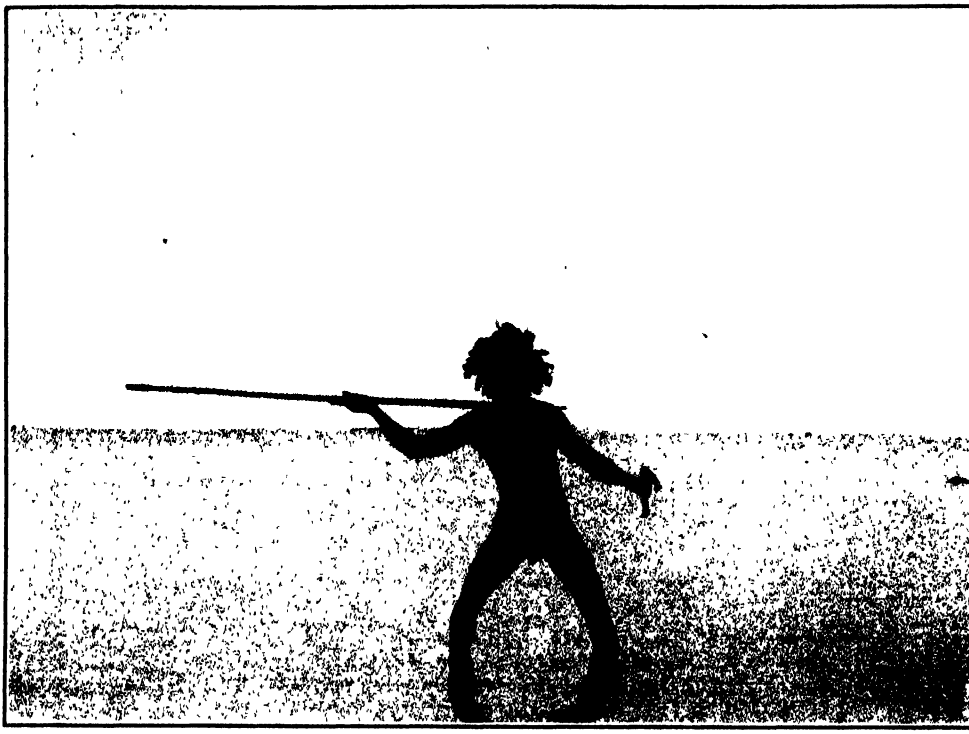
III

Speaking of the Baker Memorial School reminds me of another and very practical lesson. After leaving Fiji we were told the story of the killing of the Reverend Mr. Baker, in whose honor the school was built.

It seems that a Fijian chief visited Mr. Baker and, seeing a comb which took his fancy, appropriated it and stuck it in his bushy hair. The missionary, perhaps without due reflection, reached out his hand, removed the comb from the chief's head and was immediately killed by his followers—a most atrocious and unprovoked murder according to our ideas. But let us look at it from the standpoint of the natives.

According to their laws the chief had a perfect right to appropriate anything found in his territory. Moreover, his person was sacred from profane touch, particularly his *head;* and the violation of this tabu was inexorably punished by death according to all the long-established and recognized customs of the land. Imagine an American woman violated in the presence of her people, and we have a situation which seems to be parallel. In the eyes of the Fijians the killing of Mr. Baker was a justifiable legal execution, not a murder at all!

One of the most revolting customs of the natives of Viti Levu, as related by Wilkes, was the murder of parents by their own children, a universal custom



THEY LIKE TO ADORN THEIR HEADS WITH LEAVES.

according to his narrative. Now let us take their point of view.

The old Fijians believed in a real physical immortality. They believed, moreover, that a man lived throughout eternity in the physical condition in which he died. If aged and infirm at death, he would forever be infirm, perhaps helpless. Therefore the Fijians feared old age with its accompanying disability much more than they feared death. Hence they requested, even demanded, that their children perform the sacred filial duty of putting them out of the way. According to their tradition, law if you please, the sons were not only justified but required to perform an act which we regard as one of the most horrible of all crimes.

IV

Here we learned the lesson of the simple life, expatiated on by most writers on South Sea experiences. The details are worth our pondering, and will be of use later on. The cost of living is here reduced to a minimum and this reduction of cost means a corresponding reduction in necessary labor. The family budget is not formidable and would be something like this:

For clothing, practically nothing, as neither men, women nor children wear anything on head or feet, and Easter bonnets are unknown. The men ordinarily are clothed simply with the "sulu," a piece of cotton cloth about the size of an ordinary face towel wrapped about the loins and rolled in at the waist to hold it in place. The children dispense with even this; while the good wife wears an everyday costume consisting of a sulu of somewhat ampler proportion. But on Sunday she wears a cotton "mother Hubbard" without tucks, flounces or other extravagances.

OFFICIAL SERVERS OF KAVA AT BAU. NOTE THE HIGH-BRED FACES.

THREE BAU BELLES.

Sometimes she wears under this a tapa skirt of her own weaving. There are no millinery or dressmaking bills whatever.

For the family domicile, next to nothing. The poles for the frame are selected from the adjacent forest, and reeds fastened together in neat patterns with sennet form the inner walls of the one-room house. The roof is of thatch and the outer wall is formed of imbricating leaves to shed the rain. A single opening serves as door and window, while the floor of hard earth is elevated a foot or two above the ground and covered often with tapa mats, made at home by the women. No glass, no nails, no hardware of any sort; and no labor unions have to be dealt with, neither is there any walking delegate to make afraid!

For furniture, a few shillings to purchase a porcelain plate about two feet in diameter, in which the family meal is served; or perhaps it would be better to call it a *community* meal, cooked on the common fire out-of-doors. There are no beds nor bed-linen, fine mats of tapa cloth serving the purpose; no tables, chairs, knives, forks or spoons. Cups are made of gourds, bowls of calabashes and no individual plates are used; neither are there carpets, wallpaper, stoves or books. Of course there are no beds to make, carpets or rugs to sweep, dishes to wash or tables to set. Think of that, girls, and the women's lives are without the daily grind of endless drudgery so nerve-wearing in the case of the middle and lower classes in America.

FIJIAN STUDENTS AT THE WESLEYAN MISSION.

For food, a few pennies per week for extra luxuries not produced locally. A little patch of ground is sufficient to meet the family needs in the way of taro, yams, plantain and other vegetables; while breadfruit, mango, oranges,

A TYPICAL FIJI VILLAGE IN THE INTERIOR. (*Photo by A. O. Thomas.*)

THE OLDEST INHABITANT OF BAU AND THE "CORONATION STONE" OF FIJI KINGS.

sometimes pineapples and always cocoanuts in abundance are near most of the villages. Little meat is required, although much relished; a pig or two, perhaps a goat and a small flock of chickens are raised by the villagers themselves. Fish are plentiful near the coast and along the main streams, and the Fijians are skilful in the use of spear, fishtraps and nets. For drink, the kava made from the yangona root is universal throughout the southern Pacific. We found no evidence that it is intoxicating, although its use is confined to the men.

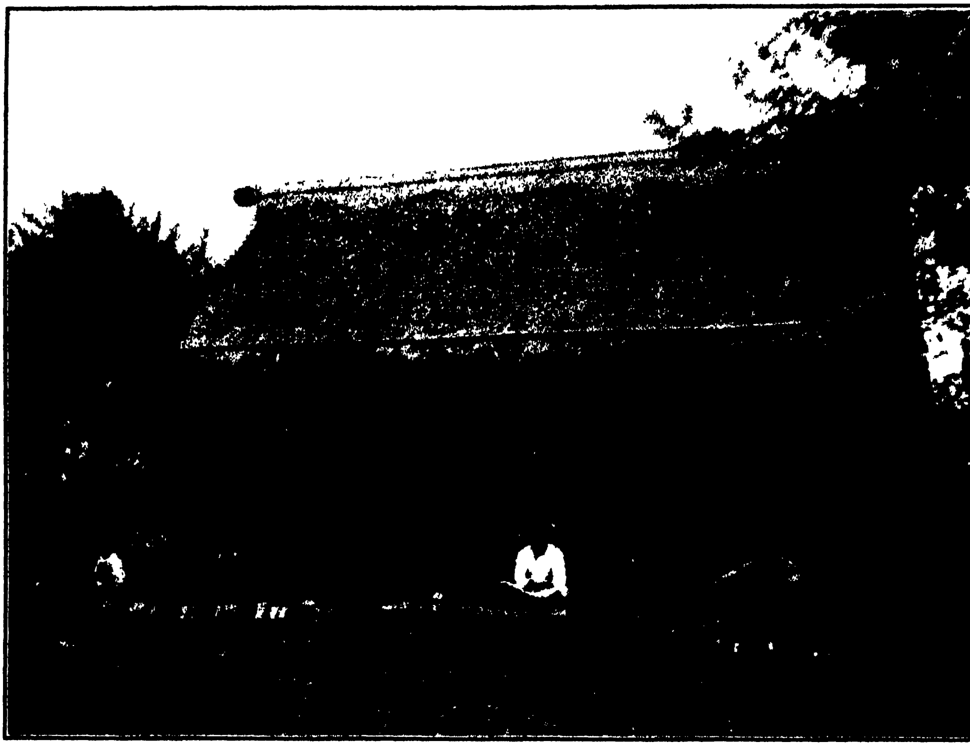
THE FIJIANS CAN WORK, AND WORK HARD, ON "STEAMER DAY."

V

These people seem content and appear to be well nourished. They live mostly out-of-doors and have enough exercise to keep them in good physical condition.

Their pleasures are simple, but apparently adequate. They sing a good deal and sing well. Occasionally they indulge in a "*meke*" or dance, but we did not see men and women dancing together. They talk, often vociferously, and enjoy it. Kava drinking is a sort of social ceremonial, and sometimes lasts nearly all night. The women are modest in bearing and seldom show sex consciousness, in which they differ from most Polynesians. For all that we could see there is little laxity in morals, and little evidence of mixture of races. The Fijians dislike the "Indians" and want little to do with them, and the whites find hardly any lure in the native women. Each race lives its own life in its own way and seems satisfied to do so.

The British officials respect and like the Fijians, who are by no means inferior intellectually. I met one barelegged and bushy-haired fellow who is an Oxford graduate, fought in the For-



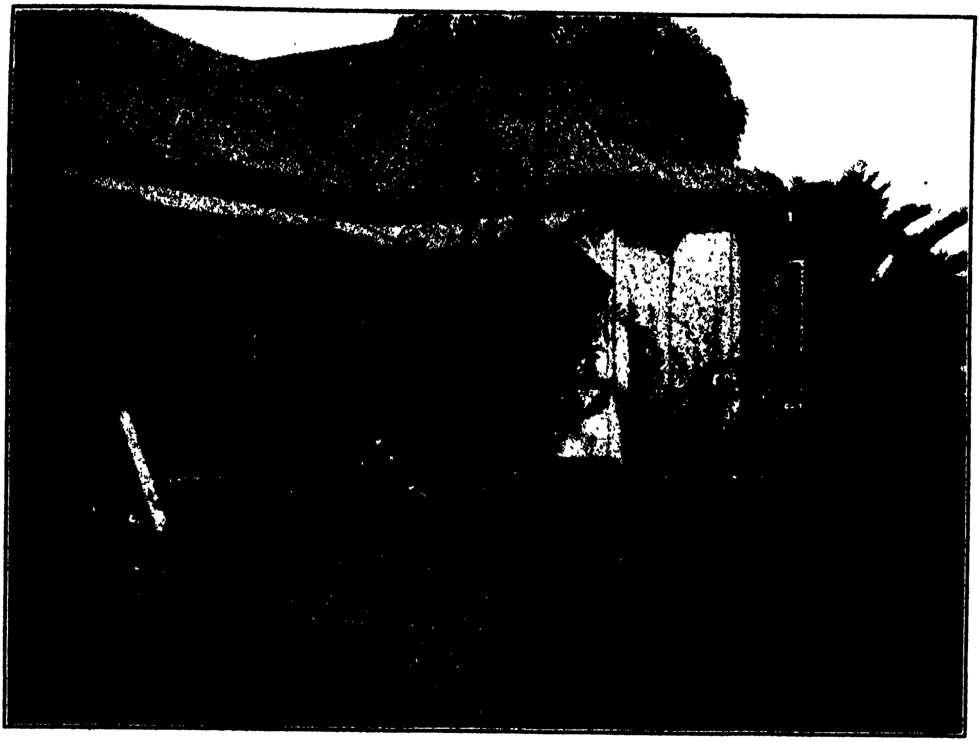
THEY ARE SKILLFUL MAKERS OF FISH NETS.

eign Legion in France, and is a scholar and a gentleman. Another, Ratu Popé Chief of Bau, showed an exquisite courtesy when I was a guest in his home, spoke as good English as any of our party, is a member of the executive council of Fiji and showed a good knowledge of world affairs. Nor am I alone in finding much to admire and something to envy in the simple life of primitive folk. Nansen and Stefansson express the same sentiment regarding the Eskimos, and O'Brien grows eloquent in describing conditions in Polynesia. In Captain Monkton's "Last Days in New Guinea" are many photographs of natives closely resembling the Fijians, even to the bushy hair. He describes one of the largest tribes, the Binandere, as a people who "though fierce, warlike cannibals were also honest, truthful, and moral to the last degree."

The contrast between the daily life of the Fijians, when removed from the Europeanized cities, and our own is as striking as can be imagined. They are the extremes of simplicity and complexity and the difference is worldwide. Is there a corresponding difference in happiness? They know nothing of the delights of the opera, nor of art in any form. Regarding their behavior Major Chapple says:

> Nothing is ever seen to offend the most sensitive observer. There are not even overtures of affection between the sexes. The women are shy and diffident. The men never leer or follow. The Fijian people might be all of one sex for all that in public is ever betrayed. Hyde Park or Brighton Beach would shock them to stupefaction. The promiscuous love scenes portrayed in the pictures reveal the whites in an unfavorable light to the astonished Indians and Fijians.

All this is so absolutely different from the stories brought back from the South



THE DOORS AND WINDOWS OF THE "FIJI CLUB" ARE PERPETUALLY OPEN.

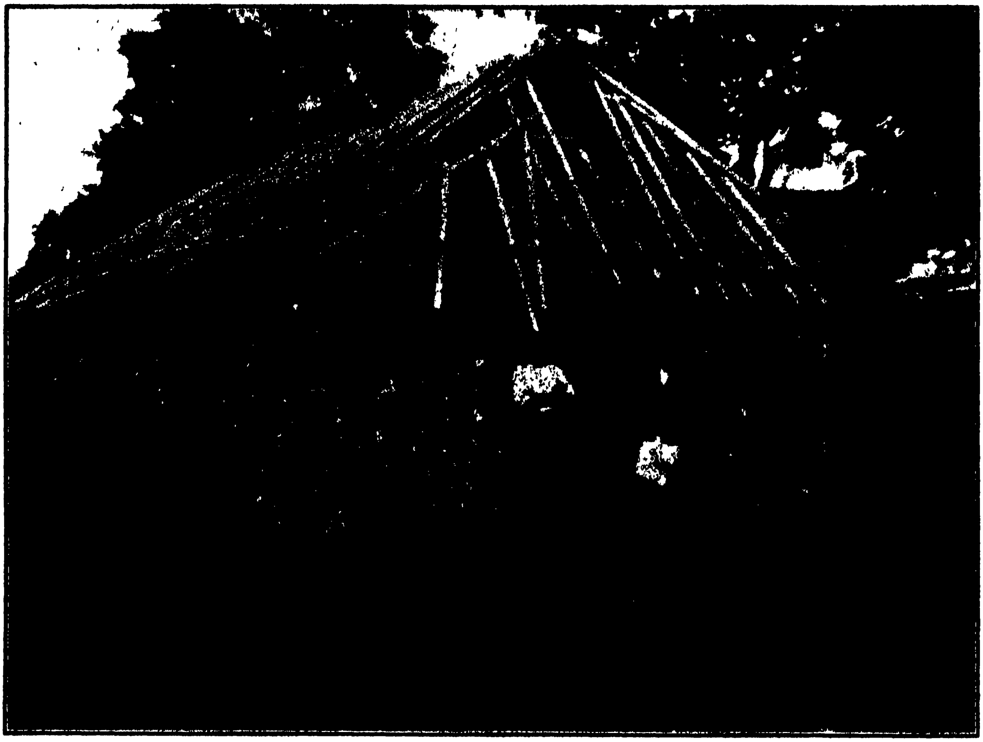
Pacific by our popular writers that it is worthy of our serious contemplation. The writer is not here challenging the truth of these charming descriptions; but does insist that it is *not* true of the Fijians!

To return to the discussion of the contrast between simple and complex civilizations: It may be conceded that we have an immeasurably greater variety of enjoyments than they, more thrills, if you please; but do we not also have an almost infinitely greater number of annoyances, anxieties, nerve-wrecking stresses and strains—to say nothing of actual want and grinding poverty? Taking it "by and large," are we happier or more unhappy than the Fijians? The answer is, of course, "Both."

Nearly all Fijians live in small villages scattered throughout the islands, and each village is a typical commune in itself, thus affording an excellent opportunity to study the nature and results of communism in its simplest expression. When the biologist wants to unravel the mysteries of the living organism he finds it profitable to focus attention on the simplest of beings which manifest the properties of that marvelous complex which we call "life." The study of the Amoeba, for instance, has given us some sort of understanding of all the fundamental properties of protoplasm, which has been called the "physical basis of life," properties which are believed to hold throughout the whole range of living things from the Amoeba to man himself. It seems evident that an examination of the communes in Fiji will enable us to understand the basic properties and natural results of the system in its more complex manifestations.

A recent writer says:

There is no ownership in Fiji, no individual ownership. All things are held in common, ex-



THE HOUSE OF RATU POPÉ, GRANDSON OF THE LAST KING OF FIJI.

cept the women—they are particular about that. If a thing is indivisible it is in the possession for the time being of the one who casually remarks, "That's a nice hatchet," or "That's a nice saddle," or "That's nice yangona."

I imagine, however, that if one man attains an object in this way another could relieve him of it by the same procedure and that there is a sort of *laissez-faire* sentiment by which is conceded practical possession of desired things by common consent. But the tenure is insecure, at best, and may be terminated by any one who cares to invoke the communal law. It appears, moreover, that a chief is exempt or superior to the law and can secure permanent possession of any coveted object that is temporarily the property of one of his people, and against this there is no appeal.

The perfectly natural result of the communistic idea is a lack of incentive to accumulate property. "What's the use," is the native's answer to such suggestion. "It wouldn't be mine if I did make it or pay money for it to some Indian." This appears to be the real reason for the reputation for laziness which these natives have among the whites. They can and will work, and work hard, as is demonstrated every "steamer day" by numerous husky Fijians, for a few shillings which they may spend on themselves or their families; but I doubt if the money is put into permanent investments of any sort.

This is, I believe, a valid objection to communism the world over. It offers no reward to individual initiative, no incentive to thrift, nothing to make it worth while to work steadily or more efficiently or embark in any enterprise that would result in added comfort or bettering one's condition.

THEIR FISH POTS AND OUTRIGGER CANOES ARE OF GOOD WORKMANSHIP.

The biologist knows that all advance in the organic world is due to the struggle for existence, or *competition*, if you please. It is the universal law of progress and applies to human affairs just as inexorably as to lower forms of life.

But there is another and more serious aspect of the case. Many Hindus, or "Indians," as they are called there, have been imported as plantation laborers and servants. For ages these people have lived in a densely populated country where the struggle has been most intense. They are industrious and thrifty and many of them have acquired property in the shape of little parcels of land and small shops of various sorts. Some of them seem well-to-do, even rich. The relations between Fijians and Indians are not cordial, to say the least. The Fijian regards himself as a better man than the Indian, dislikes him intensely and wants nothing to do with him; while the Indian has a contempt for the native and regards him as an inferior in business matters, a lazy good-for-nothing who is unable to get on in the world.

This situation between the main elements in the population is curiously like that existing in bird life in and around Honolulu. The pestiferous English sparrow from America and the ubiquitous "mina bird" from the Orient have practically driven the native birds from Honolulu and vicinity. An exactly similar situation exists regarding the human population. The Europeans from the Occident and the Chinese and Japanese from the Orient have invaded the country and the native Hawaiian race seems doomed to extinction.

THE BAKER MEMORIAL SCHOOL WAS ONE OF THE BEST BUILDINGS THAT WE SAW.

It is even so in Fiji. The British colonials on the one hand and the Indians on the other are the upper and nether millstones between which the really fine native race seems destined either to assimilation, which seems unlikely; or obliteration, which I sadly fear is probable.

The lesson, then, is that communism, although an alluring ideal, is but an iridescent dream doomed by an inexorable natural law to failure when brought into competition with a people inured to the struggle for existence by which progress is alone possible from the biological point of view.

PERSONNEL, PERSONALITIES AND RESEARCH

By Dr. CARLETON R. BALL

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For many years the writer has been concerned with the administration of research projects. During this period the conviction has been growing that, of the several factors contributing to effective research, the importance of the personnel factor has been underestimated. This seemed to be especially true of that phase of the personnel problem which may be designated as personality. The present paper is devoted to a discussion of that subject.

Research is the order of the day. The last few years have produced a flood of papers dealing with one or another of its phases or relations. The word research itself seems likely to become one of those overworked terms, a sort of shibboleth like psychology, reaction, complex and others that will come readily to mind. Without stopping here to define the term, it must be noted that not all quests for facts are to be called research. They may be mere observations, they may be surveys. Even where the experimental method is used, it does not follow that the process can be called research. It is better to separate these processes into three classes, which, in the ascending order of their difficulty, may be called experimentation, investigation and research, respectively. No hard-and-fast line can be drawn between them. They differ in degree rather than in kind. At the same time, some such difference must be recognized if we are to be honest with ourselves and our problems.

There are four chief factors concerned in every piece of research. These are (1) the problem, (2) the personnel, (3) the plan and (4) the equipment. Of these, the personnel is the most important. The problem changes as the research progresses, widening here, narrowing there, changing direction entirely from time to time with new developments. The plan necessarily changes somewhat with these shifts in the problem itself, and also with major changes in personnel or equipment. The equipment, including funds, space and apparatus, always is a variable. Much can be done with little of it; little may be done with much. Personnel is more likely to be relatively permanent, especially under any system of civil service appointment and tenure.

Varying Characteristics of Personnel

Personnel is the aggregate of all workers in an organization or attached to a project unit. The individual worker is a personality.

Certain attributes or characteristics are desirable in the research personnel. These may be grouped roughly under the two heads of training and ability. The latter is a complex. It comprises, among other things, imagination, initiative, resourcefulness, energy, persistence, judgment, honesty, accuracy, dependability, inspirativeness, loyalty and co-operativeness. If the meanings and relationships of these characteristics are studied they will be seen to fall into four groups.

Imagination, initiative and resourcefulness form the first group. They are the measures of the worker's ability to plan and to do or to interpret new things, or his ability to do or to inter-

pret old things in new and better ways. Energy, persistence and judgment form the second group. They are the measures of ability to overcome obstacles and to carry forward a piece of work steadily to its conclusion. Honesty, accuracy and dependability form the third group and, in a way, are the measure of the worker's ethical attitude toward himself in relation to his problem. The honesty mentioned here is a mental trait. Inspirativeness, loyalty and cooperativeness comprise the fourth group and are the measures of the worker's attitude toward his associates, his organization and his constituency. It is obvious that not all workers possess all these characteristics and that no two workers are likely to possess any of them in exactly the same degree.

The first and second groups are most nearly questions of ability. They are matters of the mind. The third and fourth groups are distinctly ethical in nature. They are matters of will. We recognize this dual grouping when we say one is both able and willing. One may be able but not willing, another willing but not able.

In the list of desirable characteristics discussed above, there are twelve separate items. More could have been recognized. Fewer perhaps would have served the purpose equally well. Mathematicians say there are 4,096 possible combinations of a group of characteristics varying in number from one to twelve. This suggests an amazing diversity in personalities. One person may present any one of 4,096 diverse expressions of personality, depending on the presence or absence of these attributes.

But this is not all the story. No characteristic is wholly lacking. Each one may vary in intensity, however, from near zero to the *n*th power. Multiply the 4,096 possible combinations by the possible different degrees of intensity of each one of these twelve characteristics. The possible variations run immediately to infinity and beyond. It is outside the power of the human mind to conceive this infinite variability in the human component of our equipment for research. The psalmist speaks of playing on an instrument of ten strings. We are asked to make harmony on an instrument of ten thousand strings.

Nor is this yet the entire story. A personality ordinarily is considered as virtually unvarying, the same yesterday, to-day and next year. But no! Temperaments may change their expressions from day to day, and even from hour to hour. Often there is no external sign of the existing reaction. If only humans would indicate states of feeling by chameleon colors. If only red and white traffic flashes warned us when to "stop" and "go" in making human contacts, the problem would be vastly simpler.

It is with this infinite variety of human ideas and consequent emotions and reactions that each worker must associate. It is this assembly of infinite variabilities that every administrator must attempt to evaluate, coordinate and stimulate. The task, of course, is impossible of complete accomplishment, but the motto of the researcher and the research administrator must be: "We specialize in the impossible." Ask any administrator of human activity which one of the four factors, problem, personnel, plan or equipment, requires the most thought and causes the most worry. Nine out of ten will confess that it is the personnel, if they are both thoughtful and candid. Brooks,[1] in his comprehensive discussion of "The Scientist in the Federal Service," analyzes the problem thus:

> Every administrator of research finds his chief problem in the control of his scientific

[1] Brooks, Alfred H. "The Scientist in the Federal Service." *Journal* of the Washington Academy of Sciences, 12: 73–115, Feb. 19, 1922.

personnel. To some this problem appears most simple and involves only the giving of financial support to the master mind and then allowing it to wander whither at will. Such a course, however, will not lead to the solution of a cooperative problem. Moreover, the master mind, if left to its own devices, may wander entirely off the premises. The task of the executive is to harmonize the work of a group of strongly individualistic investigators, whose tendency is centrifugal rather than centripetal. Success will be achieved by a proper balance between individualistic and cooperative inquiry. There is the danger, on the one hand, of discouraging originality of thought, and on the other, of failing to maintain the necessary unity of purpose.

The executive in the Federal scientific service stands between the horns of a dilemma. If his bureau is not so organized as to provide very definite control of the work of the individual investigator he may fail to achieve the results demanded by the terms of his grants. If his organization is such that it does not give full play to constructive thought by the individual investigator he will accomplish little to advance his science. He must constantly strive to have his administrative machinery sufficiently elastic to develop the best mental work possible by each of his scientific staff. At the same time he must not ignore his obligation to give results to the public.

It is a condition and not a theory that confronts us. We can not pass the buck if we would. Therein we are not so fortunate as Sambo and Mose. You will recall the heated discussion some years ago as to whether a fund given for general education by the head of a great corporation was tainted money or not. These two darkies were discussing that question. Said Sambo, "Mose, does you all reckon dat money am tainted?" Said Mose, "Shuah. Dat money am tainted twice. 'Taint yours and 'taint mine." The personnel problem is both yours and mine. To each worker, of whatever rank, it is a personal problem. To each administrator, of whatever rank, it is a personnel problem. Both are in honor bound to face it squarely.

Individualism and Organization

Do you wonder where this discussion is leading? Straight for the mooted question of individuality versus organization. How far is personality or the right of the individual sacred as against the right and the need of the community and the organization? The question will be discussed only in principle here. We are concerned primarily with personnel in this discussion. When it finally is answered the millennium will have come.

Paul, the great apostle, said long ago, "Bear ye one another's burdens," and immediately thereafter declared "For every man shall bear his own burden." That still is a good rule for human relations. It means, I think, that while a man must look out for himself he also has an equal duty to the organization. It doesn't seem to leave much room for the extreme individualist. I heard an eminent member of the Congress say recently, in a public address to farmers at Purdue University, that one of the things the farmer must be willing to give up, to insure the success of the new cooperative movements, was "his inalienable right to do as he damned please." This is a viewpoint by no means peculiar to farmers. It has been one of the long-cherished rights of the whole human race.

In early society the individual or the immediate family was the unit, and each did that which was right in his own eyes without regard to the welfare of other families. In the process of social evolution, the families became tribes and the tribes eventually became nations. During this process individual rights diminished and family rights increased, family rights diminished and tribal rights increased and, finally, tribal rights diminished and national rights increased. The civilized world is now in this stage of social evolution. There are many who think and pray that it is at the threshold of the next stage in this evolution where national rights will be less selfishly emphasized and international rights in-

creased. In other words, the unit of welfare has progressed from the individual and the family successively to the tribe and the nation, and now to the world of nations. Such an evolution has been taking place in our ideas of research.

Personalities are animate ideas. Ideas are the beginnings of progress. It is almost inevitable, therefore, that the beginnings of movements, institutions and organizations will be around a personality permeated by the idea involved. Striking examples of this fact have been brought out by others before me. Some one has said that every great idea was once a private opinion (the property of a single mind) and that only when it has become private opinion again (that is, the belief of the multitude) is it established. By their energy, single-mindedness and persistence to the point of self-sacrifice these strong personalities propound the idea and launch the institution or movement which carries it forward. This has been as true in scientific research as in invention, exploration, education, social reform, political emancipation or religious progress. Such development has been not only inevitable, but perhaps necessary and desirable in the formative period.

Historically, great new developments in science have been the result of individual research, discovery and invention, rather than the results of coordinated, organized, cooperative efforts. Because of the administrative dominance of strong personalities in the beginnings of research, there grew up an idea that research could be conducted only by individuals of great talent, isolated from other workers to avoid distraction and left without any administrative supervision or direction. The individualistic is the pioneer stage. Like the pioneer stage in other enterprises, it probably must be regarded as temporary, though there always will be and always should be pioneer spirits in every time and place. But for every far-reaching fundamental conception of a brilliant genius there must be hundreds of less revolutionary but equally necessary researches. Often these are complex in their ramifications and not well adapted to individualistic attack.

In studying the organization of research units or institutions two general classes are found. In one class the division or department of the institution is organized around a personality or personalities. In the other class the division or department is organized on the basis of logical and effective projects, with a coordinated personnel devoted to getting project results. These two general classes of organization are found whether we consider teaching, research or extension in our institutions of agriculture, or the varied activities of commercial agricultural organizations. Oftentimes these two classes are successive stages in the development of the same project or organization. Organization as such, whether on a personality basis or on a project basis, will be considered in a second paper. For the present we are concerned with personnel and personalities.

Defects of Organization around Personalities

A strong individuality frequently is an accompaniment of true genius, though not necessarily a proof of genius. Organization around a personality rather than around a project multiplies any defects of the dominant personality. We have noted that personalities having dominating qualities are likely to be narrowly specialized and oftentimes are extremely self-centered. Some of the defects of an organization based on such personalities are: (1) Inadequate view of the problem; (2) limited service to the supporting constituency, (3) injus-

tice to associates, and (4) perpetuation of the incompetent.

(1) *Inadequate View of the Problem*

As a project or movement develops, it becomes more complex and inclusive. The need becomes pressing for a broad survey of collateral facts, with possible readjustment of viewpoint and emphasis. Great personalities usually are men of a single idea which often becomes almost an obsession. Frequently they are unable to see the ramifying phases of the problem and its contacts with and obligations to other ideas, institutions or movements. This attitude makes for a narrow though perhaps brilliant development and not for a broad and comprehensive progress. A struggle to maintain the personal prestige may overshadow the obligation either to science or to a supporting public. No farmer having 40 acres would strike a back furrow on each 10-acre portion, plow a few furrows on either side of the back furrows and claim that his land was plowed. But such personalities come to regard their narrow strip as the whole plowland. In scientific institutions this narrow specialization of administrative leaders results in a similar condition. One line is greatly over-emphasized. Others, coordinate or subordinate, are largely neglected.

We have had the recent example of a state experiment station, in a large and wealthy state, in which the department of farm crops and soils was headed and dominated by a strong personality of this kind. Himself a soil chemist, he built up the soil section and neglected the plant section. He became internationally known and honored. His ideas of soil fertility became the center of inspiration as well as of both dogma and controversy. In the meantime he, and those associated with him, largely lost sight of other possible interpretations of soil phenomena and of the need for research on the plant as well as on the soil substrate. They carried this idea so far as to prevent the manning of their station for botanical and pathological investigation of crop plants. They neglected lines of development which comparable institutions considered important and imperative. Their staff members and graduates went out to other institutions imbued with these same narrow ideas.

When this great personality passed on it left a narrow organization unable to cope with some of the pressing agricultural problems which were present. When a crop disease broke out not long after, within the borders of this state, it became necessary to call on the federal government for help. There was no personnel or equipment within the state to deal with the problem. Reorganization has taken place, but fifteen or twenty years of valuable time have been lost because of a dominating personality with a too narrow specialization.

(2) *Limited Service to the Supporting Constituency*

Another tragedy of the narrow view is the withholding of service from the many who need. One of the oft-quoted sayings in education is that Mark Hopkins on one end of a log, and a student on the other, constitutes a university. So it does for the one student on the other end of the log, but what of the hundred other students? Is there to be no university for them? Mark Hopkinses do not occur by the hundreds. So too in the research field there is obligation to give the best and the fullest, even if it requires contact and cooperation with others. It may mean the giving up of a gratifying isolation. It was done gladly in the patriotic fervor of the war. It must be done at the less thrilling but equally challenging behests of peace-time

progress. A person of outstanding ability, but without the spirit of broad service, and the will to organize for it, is less valuable in the long run than one of lesser ability but with a broader view.

(3) *Injustice to Associates*

Sometimes dominating personalities become obsessed with their own importance. They lose the sense of comparative values of individuals. Some refuse to acquire associates who approach or equal them in rank or salary lest their own position suffer by comparison. Some will not have associates whose abilities and achievements seem in any way likely to equal or exceed their own and thus detract from their eminence. No more shortsighted and indefensible viewpoint can be imagined, especially where public funds and constituencies are involved. The result is a premium on mediocrity, or else a stifling discouragement of initiative and ability.

A related condition is that where a superior appropriates for publication, under his own name, all the material produced by his subordinates. The young worker is only a serf. Others do not go this far, but insist that their names shall appear as senior author of all such publications. Such arbitrary and unjust treatment quickly discourages the able and aspiring. On the other hand, harm may be done to young investigators by allowing them too much credit for work conducted jointly.

A corollary to the selfish attitude or character is the desire for flattery rather than the truth. This results in the evaluating of associates and subordinates by their good words rather than by their good deeds, a condition most repugnant to the self-respecting. To be obliged to associate with a toady is humiliating, but to see one in power and favor through such means is quickly destructive of morale.

(4) *Perpetuation of the Incompetent*

Another tragedy of the individualistic type of organization is that it permits the lazy, the selfish, the incapable and the obstructive to remain in positions of authority and influence. One day I sat at the desk of a fairly well-known scientist when his mail was delivered. He ran through a sheaf of letters and dropped about one half of them into the wastebasket as he glanced them through, remarking that he could not waste his time answering farmers' letters. He is now the chief teacher of his subject in another institution, but his department is turning out few able graduates. Another man of different outlook has charge of the investigations in that subject in the same institution and its research is well and favorably known.

I have in mind another institution. It has a division with two coordinate sections. The division chief is also leader of one section. In his section are five men with the doctorate degree. Nearly all are favorably, and some internationally, known for their researches. Its graduates are sought for. In the other section, equally large, there are no men with doctorates. It is not the fault of the division chief. This section is headed by a man who does not believe strongly in advanced study or in research. This standard is reflected throughout his section. Its staff members are but little known in the research field. Its graduates do not rank high. The leader of the crop section is a unique personality, widely known, but in his section an inhibitor rather than an inspirer of progress.

How long should such conditions be permitted to continue? When does the right of the individual to hold a job give way to the superior right of the institution to demand service and the constituency to receive it? The writer is not a prophet, nor the son of a prophet, but

he believes that institutional standards presently will rise above such levels.

There is another type of individualist not infrequent. He prefers the shadow to the substance. Perhaps the simile is not well chosen. Perhaps he prefers the sunlight to the shadow. At any rate, he is a better scientist in the smoking-room and the hotel lobby than in the field. He is more in evidence as an officer of scientific societies than as a publisher of scientific papers. He is not necessarily lazy, but he prefers the limelight to the laboratory. He is too good a cooperator. He has ideas, time and energy at the service of every organization except his own. He is the delight of the president who wants committee work done, but the despair of the administrator who wants research results produced. Then, to crown injury with insult, brother scientists tell his chief what a wonderfully brilliant, energetic and capable scientist he is, because they see him in effective action everywhere except in the project where he primarily belongs. He is in marked contrast to the many able workers who contribute freely of time and effort to scientific societies and still maintain a high output of project results.

Finally there is the obstructionist. He is instantly and vigorously antagonistic to any idea not his own. Obviously he can not achieve a very important position. He should lose the little he has. He is not taught by experience. He should beware or he is likely to meet the fate of the man who ate too much catsup. A small boy told me the tragic tale. The man was very fond of catsup. He ate it in huge quantities at every meal. Pretty soon one of his arms dropped off. He still ate catsup and pretty soon the other arm dropped off. Then one leg dropped off, but he still ate catsup. Finally, the other leg dropped off. Then he thought he'd better call a doctor. The doctor came and looked him over and said "You'd better look out. If you don't stop eating so much catsup something is likely to happen to you." The obstructionist is by way of being shorn of some of his powers for harm and if he doesn't look out something real is likely to happen to him.

Other Undesirable Individualities

Besides those discussed, there are many other types which present difficult problems for the administrator and for associated workers. Those illustrated below are by no means all that may be found, but they are among the more common.

The Jealous Worker

There is the jealous, suspicious worker. He is haunted by the thought that some one may receive more recognition than he, or some tribute that should have been his. He is certain that he is being discriminated against. He resents inspection of his data, and sidesteps discussion of his problem. He is angered by any success won by another. In its meanest aspect, such a character looks up his records and resents any administrative attempt to use his data in public service when he is temporarily absent.

Whetzel[2] pictures the attitude of such a worker. "One says, 'This is my idea. How shall I be protected in my possession and exploitation of it?'" Mees[3] says "The cell system (of individualistic research) tends to exaggerate the vices of such men. They tend to become secretive, to refuse cooperation, to be even resentful if their work is inquired into, * * *" As Mees points out also, it is difficult for any one else to take up the work of one of these secretive men in case of his death or resignation. For this reason, much of the investment in him may be lost.

[2] Whetzel, H. H. "Democratic Coordination of Scientific Efforts." *Science*, N. S. 50: 51–55, July 18, 1919.

[3] Mees, C. E. K. "Planning a Research Laboratory for an Industry." The Scientific Monthly, 7: 54–67, fig. 1, July, 1918.

The Narrow, Prejudiced Worker

There is another sort of scientist who has had broad training and should have broad vision but who instead is narrow and prejudiced on one or more points. It may be an unimportant matter, like dress styles or jazz or some rule of grammar or black cats, which is his pet antipathy. It may be a fundamentum of human relations or human knowledge, such as foreigners or Negroes or medical treatment or even evolution, against which he hurls all the weight of his power of reputation and personality. Because the things said by one carry much more weight than the things left unsaid by hundreds, this man of extreme prejudices has influence out of all proportion to his numbers. He leads the man in the street to dub all scientists as cranks.

Professor Kimball Young[4] tells of a professor of highest scholastic attainment with a graduating thesis so outstanding, in a subject akin to philosophy, as to receive prompt translation into French and German, and yet who was essentially a fundamentalist in his attitude toward biological science. The incompatibility of science and prejudice is well brought out by Millikan.[5]

> Man himself is just now emerging from the jungle. It was only a few hundred years ago that he began to try to use the experimental and the objective method, to try to set aside all his prejudices and his preconceptions, to suspend his judgment until he had all the facts before him, to spare no pains to first see all sides of the situation and then to let his reason and his intelligence, instead of his passion and his prejudice, control his decisions. That is called the scientific method.

The Brusque, Repellent Worker

Some persons have an almost brusque and forbidding way of talking and acting. At times it seems almost discourteous. Usually it is unintentional. Always it is antagonizing and repellent. How quickly we notice that sort of a manner at the other end of a telephone. The word we hear is "Hello," but the tone and manner say "What in thunder do you want when I'm busy!" If the person calling is a stranger, his opinion of the person or organization being called will be colored and perhaps fixed by these first impressions. When at the University of California recently, the writer was struck by the importance the university administrators placed on this matter of courteous contacts. In a little booklet[6] entitled "Suggestions for University Employees" occur the following pertinent sentences:

> Those employees who meet the students, the alumni, or the public have the greatest opportunity to communicate to the state at large the spirit of the University. * * * Be courteous and tactful. If the answer to a question of a student or other inquirer is likely to be a disappointment to him, explain the reason for the answer and, where possible, state briefly the means to be employed by him in meeting the situation. Remember that the University does not grant all requests, but that it does attempt to be just. * * * Few qualities of service have greater value than alertness. * * * Patience is needed with those persons who are not of the usual type.

Nothing can be more helpful to an enterprise than a favorable impression made on first contact. Swindlers of all kinds know this well. Shall the children of darkness be wiser in their generation than the children of light?

The Restless, Unstable Worker

There is the worker who lacks tenacity, stability, persistence. He is hard to keep on the reservation, especially when there is an unusually fine display of new scientific fireworks going on elsewhere.

[4] Young, Kimball. "The Need of Integration of Attitudes among Scientists." THE SCIENTIFIC MONTHLY, 18: 291–305, March, 1924.

[5] Millikan, R. A. "Science and Society." *Science*, N. S. 58: 293–298, Oct. 19, 1923.

[6] Anonymous. "Suggestions for University Employees." University of California, October, 1924.

Jacob (Gen. 49: 4) cursed Reuben, his firstborn, with the words, "Unstable as water, thou shalt not excell." Pearson[7] (p. 71) speaks of him frankly:

> Stability is a trait which is often given too little weight. Some of the ablest men are affected with a restlessness which impairs their usefulness. We need investigators who will devote a lifetime, if necessary, to a single problem instead of pursuing the latest scientific fad.

Brooks,[8] too, in speaking of lack of a sense of moral obligation, describes the unstable worker.

> This lack is shown by the dilettante type of investigator, who flits from one problem to another and seems to think that he fulfills all obligations if he simply remains on the government payroll.

The Dilatory Worker

The dilatory worker is always with us. He is of three kinds, the lazy, the undisciplined and the cautious. Of him Brooks[9] writes:

> Some investigators need constant spurring to obtain results, . . . the procrastinator often receives undue credit among his colleagues from the very fact that he has failed to make the evidence of his attainments public. Indeed, he often hampers the advance of science by occupying a field to the exclusion of others and by discouraging financial support for the organization to which he belongs.

The lazy type is content to float with the current. He may enjoy reading and frequently keeps well informed. He usually is a good mixer and may be also a helpful counselor on problems. But he is a laggard in producing research results, especially in form for publication, and usually does not inspire his assistants.

In the type dilatory because undisciplined, Brooks[10] would "include the investigator with a brilliant mind, which, however, is so undisciplined that it can not be made to formulate conclusions." In a sense, of course, both the lazy and the cautious also are undisciplined. The type of mind to which Brooks refers is relatively rare.

The cautious researcher who delays production of results usually is a man of excellent judgment in scientific matters, due to his habit of weighing all data with the utmost care. However, undue caution is weakness. Dr. Brooks[11] portrays him as follows:

> Most often, however, the procrastinator is the hardest working of men, and his unwillingness to put forth conclusions is due to his fear of omitting some detail or failing to fully test some theory. We must respect such a seeker of truth, yet a part of his fault may lie in a certain conceit which induces him to believe that his results are so epoch-making that he trembles for the consequences to the nation if they should be announced prematurely.

Over against these types set the researcher with an international reputation for splendid accomplishment whose manuscripts appear in a steady succession and written in clear, concise and accurate form. Yet this man admits that, for him, writing is pure drudgery, although research under difficult, unpleasant and even dangerous conditions is sheer joy. His sense of moral obligation to do always his best impels him to make his presentation as finished as his investigation.

The Over-hasty Worker

Worse than the dilatory scientists are the ones with no speed limit. Their premature, half-baked papers are everywhere before us, requiring our time and effort out of all proportion to their value. Administrative superiors who allow them to foist their unproved or half-proved theories on the public in the name of science are to blame for much of this

[7] Pearson, G. A. "Some Conditions for Effective research." *Science*, N. S. 60: 71–73, July 25, 1924.

[8] *Loc. cit.*, p. 93.

[9] *Loc. cit.*, p. 92.

[10] *Loc. cit.*, p. 93.

[11] *Loc. cit.*, p. 93.

abomination. Editors who accept papers of doubtful accuracy of conclusion bear also a measure of responsibility. Brooks[12] expresses the sentiments of many when he says:

> Another problem in personnel is presented by the scientist who is as quick as a hair trigger in publication. He boldly rushes into publicity where the more experienced investigator fears to tread and, though he may be endowed with a certain superficial brilliancy, he is too impatient to carry his researches through to the end of establishing conclusions. His contributions may be likened to skyrockets—they illuminate the scientific landscape for a moment, only to fall to earth and leave us in darkness. Such men are sometimes the pests of scientific literature, . . .

These publicity artists are indeed the pests of science. Brooks referred to them as receiving swift and sure punishment, but that is not always obvious to the onlooker.

Possible Selection of Personnel

Does the reader ask, "Why talk so much about these objectionable personalities and so little about the many splendid workers?" It is for the same reason that the daily press devotes so much space to murderers, bootleggers, bandits and bigamists, and so little to respectable and law-abiding citizens like you and me. This is not because criminals are more numerous, for relatively there are but few. It is not merely because we have a human curiosity to know the other fellow's meanness. It is because these are the problems of society, just as objectionable personalities are the problems of research administration. We all must talk about our problems.

Was it Mark Twain who said concerning the weather, "Everybody talks about it but nobody does anything about it." Is there anything that can be done about the matter of suitable personnel for research? There are three possibilities. Researchers are trained workers. Selection may be practiced on them before they begin training, or during the period of training, or after the preliminary training is completed. They may be sorted from the research standpoint while yet in high school, or during the college course, or after graduation and before entering upon investigation. Can the possibility of genius and adaptability in research be determined with any certainty in any one of these three periods? If so, the effort would seem not only to be justified but to be a definite obligation upon us. Our duty is to get the best personnel we can and to make the best use of what we get.

Selection in High School

We hear much nowadays in educational and industrial circles about selection of students and employees. Such phrases as character analysis, psychoanalysis, stimulating latent abilities, finding one's place in life, fitting the job to the man and similar ones are ever before our eyes. Where there is so much smoke there surely should be some fire. Professor C. E. Seashore,[13] head of the department of psychology in the State University of Iowa, recently has published a paper on this subject under the title "Recognition of the individual." His discussion of the need and plan for progress in this line is worthy of our thought.

> The great tragedy of all higher education today is the maladjustment, failure and misdirection of the student entering college on the towering and surging wave of "education for democracy." From 5 to 50 per cent. of freshmen fail and are eliminated in the first year. These students are sent back to home and community disgraced and disheartened, and constitute not only an economic waste, but a gross maladjustment of human energies, hopes and ambitions.

[12] *Loc. cit.*, p. 94.

[13] Seashore, C. E. "Recognition of the Individual." *Science*, N. S. 60: 321–325, Oct. 10, 1924.

For this there is a simple remedy, and that is to develop a nationally standardized college qualifying examination which shall be given at the end of the senior year in all high schools and preparatory schools as a basis of information with reference to fitness for college work. On the basis of this examination parent, pupil and teacher may make a rational estimate about the wisdom of going to college; and this examination, which is given merely for information, will be accompanied by expert analysis and advice in general principles of vocational guidance with reference to the outlook for persons of the various degrees of fitness for higher education.

Such an examination is being developed under a five-year experiment now in progress. Two thousand high school students are examined annually. Prediction of probable success is made and this is correlated with the actual achievement of those who go to college, wherever they go. Thus we shall have a quantitative measure of the degree of precision of our power of prediction. The preliminary findings are exceedingly gratifying in this respect.

Professor Ogden[14] in a paper on "The Purpose of Research" asks certain questions relating to the abilities of students. His third question is pertinent to a discussion of prospective students:

What tests can be applied to candidates for admission to the college of agriculture to determine their fitness for directing dairy work, or for agronomy, or for any other kind of agricultural work?

Curiously enough, Professor Seashore six years later (*l.c.*) provides an answer to the question in the following words:

Now at this stage we can not distinguish between the engineering and other professional or liberal arts students. It is enough to know that that student who is fitted to go to college is encouraged to do so, ...

Selection in College

The important period for determining the fitness of a man for research is while he is in the making, as a student in college. Here he is under the almost daily observation of several teachers and his characteristics as well as his various abilities may become known. In these four years a cross-section view of his future possibilities should be had. The record should go much farther than his mental progress and promise. It should contain data on the characteristics, desirable and undesirable, which have been discussed in this paper.

Ogden[15] asks the following questions regarding the working conditions favoring productive mental effort on the part of college students:

What is the necessary rest period during the course of any working day? Do students accomplish the same amount of work in the same number of days of a term, with and without vacations? . . . How shall a student know when he has reached the limits of his powers of application in the preparation of any lesson, so that a change of occupation is desirable?

Seashore[16] suggests placement examinations on entering college in order that "we shall start our student rightly at his natural level for achievement." In the third paragraph previously quoted he states that the indications given by the high school examinations are checked up during the college course. The experiments he describes are only a beginning, but they give promise that some day we shall know much more about the character and ability of college students in science than is at present possible.

Selection after Graduation

Where does the personnel of experiment, investigation and research come from and how does the organization acquire it? Trained personnel must come from the institutions of higher education. The lines of research in the U. S. Department of Agriculture and in the state agricultural experiment stations are chiefly agricultural. The personnel for this work, therefore, comes chiefly from the college of agriculture. In this de-

14 Ogden, H. N. "The Purpose of Research." *Science*, N. S. 48: 525–532, Nov. 29, 1918.

15 *Loc. cit.*, p. 528.

16 *Loc. cit.*, p. 322.

partment and in the similar institutions of some states, the scientific staff is obtained through the medium of civil service examinations and appointments. These are designed to test the ability to answer technical questions, covering a rather varied but still narrow range of specialization. This procedure is supposed to establish the fact that the prospective worker has knowledge of a subject. Appended to these examination papers are certificates of two associates, stating that the worker is believed to be of good character and fitted for the work. These merely insure that we do not acquire persons of bad moral character or with prison records, at least not without knowing of it beforehand.

But what about the possession or lack of the personal attributes named above? So far as known not one single attempt is made anywhere to discover whether and to what degree the prospective researcher has all or any of these characteristics. He may be lacking in mental honesty and accuracy. He may rank low in imagination and initiative. Such qualities as energy, persistence and judgment may be wanting. He may be selfish, suspicious and stubborn instead of loyal and cooperative. How shall these facts be known before a worker is engaged?

It would be a very simple matter to make a start. Require each applicant for admission to a civil service examination to submit the names and addresses of three or five persons qualified to give reliable information on questions of personality. To each such person send a rating sheet on which the degree of possession of certain desirable and undesirable characteristics may be clearly indicated. Transmit these estimates of character to the prospective employer with the ratings on scientific ability. It is a fair guess that in the end there would be definite endeavor to control and eliminate such characteristics as tended to prevent appointments.

It is interesting to note that for several years the experiment station subsection of the section on agriculture in the Association of Land Grant Colleges has considered personnel matters at its meetings. During the past two years, a subcommittee of their committee on experiment station organization and policy, under the chairmanship of Director R. W. Thatcher, has considered a code of ethics for station workers. At the meeting of the association in November, 1924, the revised code submitted by Dr. Thatcher[17] and his associates was finally adopted. Among other things it covers questions of honesty, stability, accuracy, promptness in publication and cooperativeness.

Concluding Questions

In conclusion, let us ask ourselves frankly if any obligation rests upon us as individuals or as an organization to better the conditions described. The writer believes that all the following questions should be answered in the affirmative.

(1) Is there an obligation upon the service to devise means by which the characteristics of prospective appointees may be more definitely estimated before appointment?

(2) Is there an obligation upon the service as a whole, and upon the individual administrator in it, to weed out the markedly unfit of whatever kind in order to improve the service and to render a more satisfactory account of his trust?

(3) Is there an obligation on administrators of all ranks to endeavor to point out to the individual employee those

[17] Thatcher, R. W., *et al.* "Report of Committee on Experiment Station Organization and Policy." Proc. Am. Conv. Assn. Land Grant Colleges, 38: 225–228 (1924), 1925.

characteristics to which they appear to be strong and also those in which they appear to be weak, and by counsel and suggestion endeavor to make each individual a better public servant?

(4) Is there an obligation on the part of the individual worker to strive to get a wider view than his own particular job, to try to get the viewpoint of the immediate unit to which he belongs, of the larger unit of which it is a part, of the entire department in which he serves and of the entire federal service as a trust to be administered of the people, by the people and for the people?

(5) Is there an obligation on the individual worker to search for their own weak spots and to endeavor to strengthen them? A rating system has been put into effect by the U. S. Personnel Classification Board in an attempt to determine the relative abilities and values of the workers in the federal service. Would it not be a helpful thing if all workers were to fill out such a rating sheet for themselves, trying honestly to determine the characteristics in which they were strong and those in which they were weak? Would not the result be a conscious effort at self-improvement?

So nigh is grandeur to our dust,
  So near is God to man,
When Duty whispers low, "Thou must,"
  The Youth replies, "I can."—*Emerson.*

SUCCESS

By Professor A. S. PEARSE
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WHAT every man most desires is to be successful. What puzzles most of humanity is how to do it.

If one asks a business man for the secret of success, he says, "Boy, make money—and save it!" If the socially successful one is "among those present" at the most "stylish" functions and can associate with "aristocrats," she has "arrived." The scholar works years in order to publish a few pages that he hopes may be commended, perhaps a century later, by some fellow of like kidney. The rector asserts that if one is good and trusts in God, nothing else matters. The politician strives to "manage the masses." Which of these is seeking real success?

The New York *American* cleverly remarks, "Success is getting what you want; happiness is wanting what you get." Professor Witmer, who is a psychologist and should know better, says that success is the attainment of "what the individual himself deems worth while."

Such primitive attitudes of mind of course amuse biologists. We have long known what success is, and we regret that a youth who is trying to attain some degree of mental stability can read, as the opinion of a competent scientist like Professor Witmer, that success is only that which makes an individual satisfied with himself. All biology cries out that success is more than that! One with a scientific attitude of mind and who is continually trying to think clearer can not be satisfied with any epigrammatic, or even with an inadequately pragmatic, definition of success. Real success is a continual reward and a continual obligation.

Without competition there can be no success. Victory depends on winning a race or a fight or some other contest for a leading position. So far as it applies to the lives of men and other animals, success is usually the product of intention and effort, not the result of luck or chance. In the language of Charles Darwin, it is excelling in a struggle. A current dictionary says it is "the successful issue of a thing attempted."

In order to make the biological aspects of success clear, the reader is invited to consider briefly the characteristics of a successful plant and a successful animal —the dandelion and the housefly. From a biological point of view the *survival* of a particular species of animal in the struggle for existence may be considered as evidence of a certain level of success-- if an animal is alive, it is to some degree successful. If a species also occurs in great numbers and is able easily to make a living over a considerable portion of the earth, it is to be looked upon as having attained a higher level. Any one who has practiced swatting flies or tried to keep a neat lawn knows that the fly and the dandelion have won many victories over the human race. In fact, from man's point of view, they are ubiquitous, disagreeable pests that ought to be eradicated but have not been just yet. They have beaten man—old *Homo sapiens* himself.

What is the secret of the success of these organisms? Our enemy, Sir Fly, is keen of sense, agile, versatile. Having his skeleton on the outside and his muscles within, he has done what human mechanical engineers say is the best thing for him—*i.e.*, gradually through the ages become small and quick. Now

he is able to occupy a considerable part of the little nooks on the earth. He escapes with ease from the attacks of sluggish, bulky animals that have bunches of soft muscle on their exteriors and bones within. Among animals of his own kind Sir Fly represents the best that has been produced. Mechanically his equipment for struggling shows the highest degree of perfection. He has the "latest models" of wings, eyes, feeding organs, legs, etc. To be sure, Sir Fly's shield has a bar sinister across it and his escutcheon bears a blot or two. Some of his ancestors were awkward worms with legs through the whole length of their abdomens. They had no smooth and rotund surface like that his highness polishes so proudly to-day. Sir Fly's great-grandfather was glad to gnaw food off in great chunks and bolt it down, instead of delicately rubbing it into polite bites with a beautiful rasp-ended tongue. But while biologists like to rake up these scandals about Sir Fly's family, we have to admit that he stands to-day the peer of any insect, and ever our astute and capable enemy.

But this is not all—Sir Fly has kept his versatility. Equipped with all the best types of arthropodan structures, he is not confined to one narrow mode of life. The poor honeybee has put all his eggs in one basket. If he can not find sugar to eat, he is lost. But our enemy, Sir Fly, can eat sugar or meat or fat or any mixture of such foods, and flourish. A bee's egg that is separated from its brood comb and its attentive swarm of nurses produces a little grub that soon perishes. A fly maggot can live on a wide variety of foods and withstand great variations in moisture, temperature and other conditions of environment. It is apparent that there must always be more flies than bees in the world. We men may not like to do so, but have to admit that Sir Fly is a success. He fights, survives; yes, he dictates: Build screens on your houses, boil your water, cover your food!

Our enemy Baron Dandelion is equally perfected and versatile. In his physical makeup are tubes for carrying milky secretions; polygonal, spiny pollen grains that do not easily roll off when they lodge on a stigma; aeroplanes for transporting ripened seeds—many of the latest developments in plant structures. If we order the baron off our estate, he digs deep to a water supply, spreads out flat to keep our allies away from his commissary, and makes a stubborn fight. On the other hand, if he appears in our flower garden, he does not spread out at all, but grows up tall and thin. Baron Dandelion is not an unprogressive, stubborn bigot, either, but a keen, resourceful enemy. One instance of his progressive spirit, and we will let him pass. Through long years and ages dandelions have been developing beautifully colored flowers—composite flowers of the most specialized type—but recently these flowers (though still retained and accorded a certain position on account of an edict from King Heredity) have lost their function. Their bright colors are now of no avail. Like so much archaic machinery in a progressive factory, they have fallen into disuse because dandelions learned to fertilize themselves, and therefore the mechanisms associated with cross-fertilization are no longer necessary.

All this introduction leads up to Theorem I in the Biological Book of Success:

Theorem I. *Successful and progressive plants and animals survive in the struggle for existence by being specialized, yet versatile.*

There are many who have false standards for success or are satisfied by pseudo-success. For those who say, "Why struggle when it is not necessary? Why not invent something, or write a book and live on the royalties?" I can only answer that there is no greater biological sin than to cease to struggle. It is not wrong to have a billion dollars or a presidency or a title or a good name.

The unpardonable sin is in saying, "I have done enough," or "I have enough," or "I have earned a rest." Biological evidence for this point of view is to be found in the past history and present lives of many animals. Coming from swimming ancestors with eyes and other organs that gave some degree of appreciation of the world, the barnacle to-day lives attached to rocks along the seashore, safely encapsuled in a stony wall, kicking its legs in the water to capture food. Certainly the barnacle has a sure supply of food and an easy life. Again, the tapeworm leads a quiet, protected life in the midst of digested food. Indeed, it lacks organs of digestion completely and has no sense organs for finding food, or for recognizing other particular qualities in its surroundings. Tapeworms appear to have descended from ancestors that lived a free life, seeing, seeking, fighting for their place in the world. Why not be a parasite? There is some prejudice against it, but why not?

Theorem II. *The degree of ability and appreciation that any living plant or animal possesses is more or less directly proportional to the amount of struggling that the organism has done. Lack of struggling is always associated with degeneracy, with loss of power and of accomplishment and appreciation.*

Then there are those who would condone another damnable biological sin—deceit. A man says: "I have got to make a living. What harm if I deceive the world to do it; especially if I actually injure no one?" Deception has long standing as a means of existing among animals. Spiders spin delicate webs that are overlooked by careless or stupid insects. Decorator crabs cover their backs with objects that they select from the sea bottom and thus escape detection. A walking stick is camouflaged in form and color to resemble a twig and puts all its faith in this resemblance. If one of these insects is disturbed, it may hold the same position for several hours (if it moves, it no longer resembles a stick) and will allow its body to be cut in two without giving any sign of life. If such means secure a living, why not use them? From a biological point of view they may be said to be expedient, but dangerous, because animals employing them are led to depend more and more on special means, and if deception is discovered, the game is up. Prolonged rains may prevent the building and repair of webs, and spiders starve. If a decorator crab falls on a clean sandy bottom and attempts to move about, it is discovered and snapped up by some hungry fish; if a wind carries a walking stick away from twigs and stems, it is easily seen. If an actress that depends on a $10,000 gown to win her audience loses her trunk, she loses her audience too. If a shyster lawyer or a quack doctor is found out, the law removes his accustomed means of livelihood.

Theorem III. *Avoiding the struggle for existence by deception is dangerous because plants or animals that use such methods tend to become dependent on special means and if these are discovered, organisms will be greatly handicapped or eliminated from the struggle.*

Another means of struggling is through the cooperation of many individuals. Men, ants, termites and other animals have attained considerable success with this method. It undoubtedly has the advantages of the strength that comes with united effort and the high degree of attainment that is possible through the work of cooperating specialists. In ant colonies structurally different castes are present, which are specialized as workers, soldiers, doorkeepers, etc. In general the cooperation that is an essential feature of social life is beneficial to the colony, but it always entails a lack of opportunity for the full development of the individual. Communism tends to reduce all to the same level of mediocrity and makes the development of outstanding individuals more difficult.

Another great defect that is always associated with social life is parasitism. No two individuals are ever of equal ability and some members of any community are abler and do more work than others. Some individuals are so incompetent that they contribute nothing and are supported by the community. Furthermore, real social parasites intentionally insinuate themselves into communities, where they make no attempt to do anything but make a living for themselves. Some two thousand species of social parasites have been recorded as occurring in ants' nests. In human societies there are always parasitic individuals or castes which shout for cooperation and gain a living from others, but contribute nothing themselves.

Theorem IV. *Cooperation is one of the best means of attaining success if it does not involve too great sacrifice of individuality or waste effort on social parasites.*

The animals that lived in past ages give some insight into the meaning of success. At one time marine invertebrates dominated the earth. Then the old ostracoderms and fishes came in and were the most astute and capable animals for a time. Later amphibians appeared and were able to invade parts of the earth that fishes had never reached because they acquired the ability to breathe air and hence could go on land. Then came the Golden Age for reptiles, and hundred-foot monsters roamed over the continents. These gigantic animals ran their course and were succeeded by the smaller, but swifter and wiser, birds and mammals. Probably the dominant animals in each age patted each other on the back and said, "How good we are! There has never been anything like us before!" Most of them are wholly extinct and the earth will never feel their influence again. If you ask a paleontologist what the usual cause for the dying out of a race of animals was, he will probably answer, "Too much specialization." The dinosaurs, for example, attained gigantic size, but were unprogressive in other lines of development. The earth environment changes markedly from time to time—there have been glacial epochs, humid periods, arid periods, etc. If an animal is highly adapted to peculiar conditions and these change, the animal becomes extinct. Every one knows that in human society too much specialization is unwise. A city blacksmith who has done nothing but make horseshoes all his life may find it difficult to make a living in his old age because he is ignorant of the ways of repairing automobiles.

Theorem V. *Specialization is desirable but must not be so narrow that an animal can not take advantage of new types of opportunities and change activities with changing conditions.*

Enough of argument! Now, what is success? The evidence from biology acclaims to the world: "Struggle and improve. It is sinful to be narrow, lazy (or even contented?), deceitful or blindly cooperative. It is virtuous to be industrious, ambitious, honest and considerate." Probably the most important tool for success is eternal trying. Men succeed in all fields of human endeavor and often do not realize how they have reached their goal. President Eliot, who was trained as a chemist, ascribed his success to hard work; the great general, Napoleon, to foresight; the business man, Bradley, to necessity; the evangelist, Moody, to cooperation. Holmes showed his wonderful insight when he said:

> I find the great thing in this world is not so much where we stand as in what direction we are moving. To reach the port of Heaven we must sail, sometimes with the wind and sometimes against it, but we must sail, and not drift nor lie at anchor.

Law. *Success is continual improvement.* It is also the most important milestone on the road to happiness.

WHAT SCIENCE OWES THE PUBLIC

By AUSTIN H. CLARK

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WE have heard much, in recent years, of what the public owes to science. The telephone, the automobile, the aeroplane, the radio, the X-ray and many other things, commonplaces at the present day, are commonly brought forward as concrete examples of groups of correlated achievements in pure science now finding practical application for the good of all.

Nobody has denied, or could deny, the appreciation of the public for these benefits. It is evident in popular books, in the magazines and in the daily press in ever-increasing volume. The evidence consists of a flowering of interest in science in this country, which is without precedent in this or any other land.

These startling achievements, all products of pure research, have forcibly impressed upon the public the concrete significance of science to itself.

Science has become democratized, and by so doing has chiefly been responsible for that fundamental change that has taken place within the last few years in our social system obvious to any one with any powers of perception aptly called by Professor Carver a social revolution.

This social revolution has resulted in a wonderful improvement in the condition of our so-called humbler classes over what it was even two decades ago. The incomes of the small tradesmen and the laborers, now actually large and made relatively larger still as a result of greatly increased efficiency in the production and distribution of the products of our farms and industries, due to the broad and general and increasing, though commonly unnoticed, application of scientific facts, now permit them to enjoy very many of those luxuries which even fifteen years ago were considered as possible only for the rich. The automobile, the "movies" and the radio, the telephone and a host of other things now are regarded as essential to the well-being of a very large percentage of our population.

These luxuries of the very recent past, now become essentials, all have one thing in common. Their use of necessity results in a broadening of contacts.

Broadening of daily contacts goes hand in hand with broadening of interests and of vision. We are beginning to discover that what we hitherto have called superior intelligence is very often nothing more than the mental attitude produced by more numerous and more intimate contacts with the varied activities that take place beyond the normal orbit of one's daily life.

Now that they share with their more affluent fellow countrymen most of the material luxuries of life, those occupied with the humbler lines of work are sharing also more and more in their mental attitude toward science. They appreciate its benefits, and they wish to learn all they can about it. And this desire for enlightenment is coupled with increased insistence that what they learn be accurate.

Here is the great responsibility of science in this country at the present time, to take the public into its confidence and to inform it of what is going on, to form a partnership between the scientific workers and the great mass of the people which shall result in mutual benefits.

Why is this necessary? Because in any country progress in science is and

always has been dependent on the active appreciation of an interested public. The theory that it is the hobby of the rich and leisure classes and that it can be advanced effectively by the restricted patronage of a Louis XIV is quite untenable. Isolated steps may be taken in such a way, but a great sound body of science can no more be built up without the interest and backing, indeed even the participation, of a large section of the public than the cathedral of Chartres could have been built by the nobles of Beauce alone.

No one can deny that England, with her Newtons, her Faradays, her Darwins, her Lubbocks, leaders in every branch of science, holds first place in the discovery of basic scientific principles. It is equally undeniable that interest in science among the population as a whole is, or at least until recently has been, greater in England than in any other country. In England there exist very many scientific societies with a membership made up largely of working men and tradesmen. The relationship between these two sets of facts is beyond question.

What were, and are, the conditions in America? Fifty years ago this section of the public was relatively small; the majority of the people took little interest in anything further than getting enough to eat and the most elemental comforts. Their outlook on the world at best was purely local, and generally they paid no heed beyond an idle curiosity to affairs outside their daily round of life in their own town or state.

The modern developments in transportation and communication, especially the organization of these services into units nation wide and even international, has changed all this. The great majority of our population is now awakened and alert; no longer apathetic, our people wish to know what science is and what it means to them.

In the old days science in America was for the most part the recreation of the rich or well-to-do, and these were the only classes interested. Conditions are quite different now. Why? Because the more or less isolated scientific facts developed and established as a pastime by the leisure classes in the past have now been correlated, formulated into broad principles, further elaborated and applied for the good of all. Science itself has brought about this change by attracting the interest and gaining the confidence of an ever-increasing clientele.

But by doing this science has brought upon itself a grave responsibility, that of satisfying the interest it has itself created. Why is this true? Because of the dependence of science on intelligent popular appreciation. This dependence is at once apparent in all those institutions that are supported by federal or state appropriations. It is at once apparent also in the great industrial concerns that sell their products to the public. It is less apparent in institutions supported by endowments. But if such institutions are popularly believed to serve the public interests their endowments will increase proportionately; if not, they gradually will decrease in influence and possibly will be cut off altogether. Though not so obviously or so immediately responsive to the popular will, endowed institutions are nevertheless ultimately dependent on it, and that dependence is becoming more and more pronounced.

Here we seem to have an impossible situation, institutions engaged in specialized research work dependent for support upon a public with no knowledge of the intricacies of the subjects studied. How can they ever get together, as they must if what has just been said is true?

How was it that isolated scientific facts were assembled, coordinated and applied for the public benefit? This

came about not through the work of the scientific men themselves, but through that of intermediaries, jobbers if you will, men more of business than of science, who visualized the possibilities in the mass of facts available and made use of them.

In the same way the results attained by the research worker must be coordinated, sifted and interpreted to be intelligible to the average man.

It is a common fallacy that progress in science has resulted from the labors of devoted individuals working long hours by themselves, mostly without adequate reward. This is not so. It is quite true that the great bulk of scientific detail has been gathered by men of whom the public seldom hears, men wholly devoted to their work and deserving of the highest praise for their disinterested labors. But the busy world has little time to ponder and appraise their efforts in detail.

Progress in science has resulted from popular appreciation of its interest and value. This has been brought about through the work of intermediaries able to explain it to the populace at large. Just as science has been applied for the common good by men who were rather business men than men of scientific bent, so science has mostly been explained by publicists rather than by research workers.

The great men in science have been those like Lamarck, Agassiz, Darwin, Huxley, Tyndall, Rayleigh, Lubbock and many others, who were both scientific men and publicists combined, outstanding research men who wrote and talked in terms the average intelligent man could understand, secured his interest, and thus made the work of all the others possible. It made little difference whether these men were right or wrong in their ideas. They secured the public interest; this once aroused, infinite discussion was made possible and all the facts brought out. Millions of dollars have been spent by publishers of books, magazines and newspapers in printing material bearing on Darwin's work. Thousands of scientific men, under the stimulus and protection of the interest thus aroused have brought innumerable facts to bear upon the subject.

So much for the intermediaries of the past. What of those to-day? At the present time we have a vastly extended and more alert interested public, anxious to be informed and also anxious to know how they are affected by developments in science. We have an ever-increasing number of devoted men engaged in highly specialized work of whom the general public never hears, but whose work is of the most fundamental and vital character, and forms by far the largest and most important part of our scientific output. We have no lack of able men, like Millikan, Merriam, Michelson, Howard, Osborn, Shapley and many others who, leaders in their several lines of science, have not lost contact with their fellow men and can therefore speak to them in simple language that they can understand, carrying ever forward the work of their illustrious predecessors. And we also have a growing corps of writers, capable, honest and sincere, whose one aim and desire is to further science by describing and explaining in the magazines and newspapers the new discoveries now almost daily made.

Many of our scientific men are apt to look a bit askance at these representatives of the press. They doubt their honesty of purpose and their ability to report correctly what they hear. For the most part the fault lies with the scientific men themselves, who are unable to explain their work in such a way that it can be understood by others who approach the subject from a wholly different angle. It is a common human failing to explain one's weakness to oneself by assuming that the fault is with the

other fellow. Most of us fail to see in a misquotation in the press a reflection on our own clarity of expression, though that is very often what it is.

Let us compare the research worker with the publicist. We who are immersed in research know that before we can produce results of value in their broader application a probationary period of from ten to fifteen years is necessary, even after an intensive college education. Always to every man the other fellow's work seems easier than his own, since he sees only the outstanding features and is ignorant of the maze of detail on which these are based.

The successful scientific man too often looks upon the publicist as a sort of lucky being who by the easy process of writing for a few hours every day can command a handsome income.

The successful writer knows too well that years of patient unrewarded effort full of discouragements of every kind, a grueling apprenticeship more severe than that of the average scientific man, working usually under the protection of some powerful institution, must pass before he finds his place.

He on his part, remembering these years of bitter strife, is prone to regard the laboratory worker as leading a life of ease and comfort, if not, indeed, of semi-idleness, protected by his institution from the jealousies and envies of his fellow men.

What science owes the public is a greater extension and expansion of all lines of contact with the people as a whole. Let us show more confidence in our fellow men. Let us be frank and open with them. If we who are engaged in science let the people know what it is we do and what it means to them every one will profit.

THE VITALITY OF THE PEOPLES OF SOUTHERN INDIA, ITS CONSERVATION AND PROMOTION[1]

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The Peoples of Southern India

To the untrained eye of the ordinary untraveled European on first arriving in Southern India, all Indians are black, all have the same cast of countenance, and all except the "decently naked" labouring classes wear loose garments which revive dim memories of the attire of the ancient Greeks and Romans. The first step in the observant man's education is to learn to tell a Hindu from a Mohammedan, and a further stage is reached when it dawns upon him that the upper classes of Hindus are much fairer than the lower, and that their features are moulded on finer lines. Later on, as opportunity favours him, he learns to distinguish what may be called the provincial types of the people of India.

The skin color of the different types presents extreme divergencies, that of the Dravidians of Southern India being bright black, and aptly compared to the color of strong coffee unmixed with milk. "Of the Irulas of the Nilgiri jungles some South Indian humorist is reported to have said that charcoal leaves a white mark upon them." Amongst the higher castes, of course, the skin is frequently quite fair. The hair of the great mass of the population of South India is black or dark brown, but carroty hair is not unknown among the Syrian Christians of Malabar and South Travancore on the west coast of the peninsula.

The nasal index, *i.e.*, the relation of the breadth of the nose to its length, gives a very accurate gradation of racial type. For those parts of India, like Madras Presidency, where there is an appreciable strain of Dravidian blood, it "is scarcely a paradox to lay down as a law of the caste organization, that the social status of the members of a particular group varies in inverse ratio to the mean relative width of their noses. The broad nose of the Negro and of the typical Dravidian is his most striking feature, and, in fact, the typical Dravidian as represented by the Pahars of South India has a nose as broad in proportion to its length as the Negro." Some writers, indeed, describe the Dravidian under the name of Negroid, but the two are in no way related.

In Southern India the stature is generally lower than in the plains of the north, the minimum being found in the Negritos of the Andaman Islands, and the mean as low as four feet ten and one half inches.

Of the seven physical types mentioned by Risley, the Dravidian is to be found in that part of India stretching from Ceylon as far north as the United Provinces and Central India. When Madras, however, is called the Dravidian home, that does not mean that all the people of Madras are of the predominant type.

From time immemorial a stream of movement has been setting from north to south, a tendency impelling the higher types towards the territories of the lower. During the course of the movement, Indo-Aryan types have spread all over India as conquerors, traders, landowners; and in Madras, which is furthest removed from the Indo-Aryan settlements in North-West India, members of the upper castes are still

[1] Papers from the Department of Biometry and Vital Statistics, School of Hygiene and Public Health, Johns Hopkins University, No. 112.

readily distinguished by their features and complexion from the mass of the population.

The Dravidian race is the most primitive of the Indian peoples, occupying as it does the oldest geological formation in India. Huxley considered that the Dravidians might be related to the aborigines of Australia, but Sir Wm. Turner's later studies have cast doubt on their Australian affinities. "The present peoples of Southern India are therefore a mixture of the ancient Dravidians with the invading Indo-Aryans, the type being precisely what might have been expected to result from the incursion of a fair long-headed race traveling by a route which prevented women from accompanying them into a land inhabited by dark-skinned Dravidians. The degree of intermixture varied," but writers of the Indo-Aryan school maintain the predominance of the Dravidian element in the present population.

The Hindus of Southern India, numbering in all about 37 millions, may be divided into four great classes or castes, *viz.*, the *brahman*, the *shastriya*, the *vaisiya* and the *sudra*, the lowest of all. In order to give some idea of the complexity of the social system involved in the word caste, an illustration used by Sir Herbert Risley some years ago may be adopted.

Take the great English tribe of "Smith," the "noun of multitude," as it has been called, and imagine it transferred into a caste organized on the Indian model. The caste would trace its origin back to a mythical eponymous ancestor, who took his name from the smooth weapons he made for his fellow tribesmen, and, bound together by this tie of common descent, they would recognize as the cardinal doctrine of this community that a Smith must always marry a Smith and could by no possibility marry a Brown, a Jones or a Robinson. Over and above this general canon, three other modes or principles of grouping within the caste would be conspicuous. First, the entire caste of Smith would be split up into a multitude of "in-marrying" clans, based on all sorts of trivial distinctions.

Brewing Smiths and baking Smiths, hunting Smiths and shooting Smiths, temperance Smiths and licensed saloon Smiths, Smiths with double-barrelled names and hyphens and Smiths with double-barrelled names without hyphens, democratic Smiths, republican Smiths, tinker Smiths, tailor Smiths, Smiths of Maine and Smiths of Maryland, "all these and all other imaginable varieties would be crystallized by an inexorable law forbidding the members of any of these groups to marry outside its own circle." The "dry" Mr. Smith could only marry a "dry" Miss Smith and might not think of a "wet" damsel, the free trade Smiths would have nothing to say to the protectionists.

Secondly, within each class we would find a number of "out-marrying" groups governed by the rule that a man of one group could in no circumstances marry a girl of the same group, *i.e.*, the converse of the first. In theory each group would be regarded as a circle of blood kindred, and marriages within the limits defined by the group name would be deemed incestuous. In these circumstances the group name descends in the male line and would of itself present no obstacle to a man marrying his grandmother. Thirdly, each marrying class is broken up into three to four smaller groups which form a sort of ascending scale of social distinction. Thus the class of hyphen-Smiths, the cream of the caste, would be again divided into, say, Episcopalian, Presbyterian and Salvationist hyphen-Smiths. The rule would be that a man of the Episcopalian group might marry a girl of his own or the other two groups, a man of the Presbyterian group might marry into his own and the Salvationist group, and a man of the Salvationist group might marry only into his own group. A woman could under no circumstances marry down into a group below her own. Other things being equal, two thirds of the Episcopalian girls would get no husbands, and two thirds of the Salvationist men no wives. If we suppose the various aggregates of persons bearing the two to three thousand commonest English surnames to be formed into separate castes and organized as above, the mental picture thus formed will give a fairly adequate idea of the bewildering complexity of the Indian caste system.

Even Christianity has not altogether escaped the subtle contagion of caste,

and everywhere in India there is a tendency for converts from Hinduism to group themselves according to the castes to which they originally belonged. That is more true of the Roman Catholics, as the Catholic Church tolerates this idea of caste, while the Protestant Church condemns it. There seems to be no likelihood of caste being banished from Indian soil "until Brahmanism itself—*the fons et origo mali*—has died a natural death by the use of the scientific spirit, and the fallacy of its pretensions has become an object of general scorn." As soon as the Brahman begins to disappear, the rest will follow.

The following table, giving the numbers of caste sub-divisions among six of the chief castes for the four main languages of Southern India, will demonstrate the complexity of the system:

	Tamil	Telegu	Malayalam	Canarese
Brahmans	43	80	20	80
Vellalars, or agriculturists	175	404	55	169
Chettiars, or merchants	59	29	13	17
Kshatriyas, or warriors	13	17	5	14
Shepherds	48	85	17	42
Accountants, or statisticians	11	23	2	2

TABLE I

The Mohammedans, who number nearly three millions in Southern India, are in every respect the antithesis of the Hindus.

The Mohammedan religious ideal is strenuous action rather than hypnotic contemplation; it allots to man a single life and bids him live it and make the best of it. Its practical spirit knows nothing of a series of lives, of transmigration, of *karma*, of the weariness of existence which weighs upon the Hindu mind. The Mohammedan religion is opposed equally to the Hindu scheme of a hierarchy of caste, for in the sight of God and His prophet, all followers of Islam are equal.

The contagion of caste, however, has spread even to the Mohammedans, and, in Southern India, one meets with a large number of low-class Mohammedans evidently the result of proselytism among the pariah Hindus, and whole castes have been known to become Mohammedan because the Brahman would not allow them to enter the Hindu temples, but compelled them to worship outside. Even to this day there are certain streets along which none but Brahmans may pass.

Christianity has had considerable success in Southern India, especially among the depressed classes, there being over a million Christians now in Madras Presidency. "To the pariah it promises release from a relentless form of social tyranny, the tyranny of caste, and it offers them independence, self-respect, education, advancement and a place in an organized and progressive society." As a matter of fact, the pariah, whose mere vicinity pollutes, has traditions which point to the probability that his status was not always so degraded as we find it at the present day.

LANGUAGE

The people of Southern India have, therefore, no community of origin. Moreover, there is little community of language. The great mass of the population speaks either Tamil or Telegu, the former being found mainly in the southern districts, and the latter in the northern area. In addition, a very considerable proportion use the Canarese language, whilst to the southwest a language called Malayalam is spoken. All these tongues are more or less interrelated, being probably derived originally from the same mother tongue, but to-day a Tamil does not understand

Telegu, nor does the Malayalee automatically find it possible to communicate by word of mouth with a Canarese. The one common language in South India is English, and the writer is personally acquainted with an Indian married couple whose only means of linguistic communication is English. Most Mohammedans use the Urdu language just as they do in Northern India. As a general rule, it is necessary to be acquainted with at least two languages in order to be able to carry out peripatetic work such as must be done in the field of public health. As both the Tamil and Telegu tongues have a rich store of ancient literature, both having absorbed a great deal from the Sanskrit, it is as unlikely, as it would be regrettable, to expect that South Indians will ever adopt any one common language.

Diet

As regards food, the Madras Hindu is a strict vegetarian, rice being his staple form of diet. This is supplemented with varying quantities of green vegetables, milk and ghee, which is a form of clarified butter. The orthodox Hindu would be horrified at the idea of eating any other form of fat than ghee, but the Indian merchant is familiar enough with methods of food adulteration, and considerable quantities of so-called pure "ghee" contain high proportions of mutton and beef fat, whilst pig's fat is also not entirely excluded. The vegetable part of the diet being not always available for different reasons, and the better class Indian expressing a preference for highly polished rice, it is not surprising that beri-beri is fairly common, the more so as all milk is boiled before being consumed. Osteomalacia is not uncommon.

Vital Statistics

The population according to the census of 1921 was 41,002,696, of which Hindus comprised 36,687,777, Mohammedans 2,831,361, native Christians 1,312,060, and other classes 171,498. The percentages of each to the whole are Hindus 89.48 per cent., Mohammedans 6.95 per cent., native Christians 3.2 per cent. and other classes 0.04 per cent. Censuses have been taken every ten years since 1871, and with the figures for these a population growth curve has been prepared. (Fig. 1.) While it is not possible to fit this curve very accurately with such a small number of observations, yet it probably is reasonable to assume

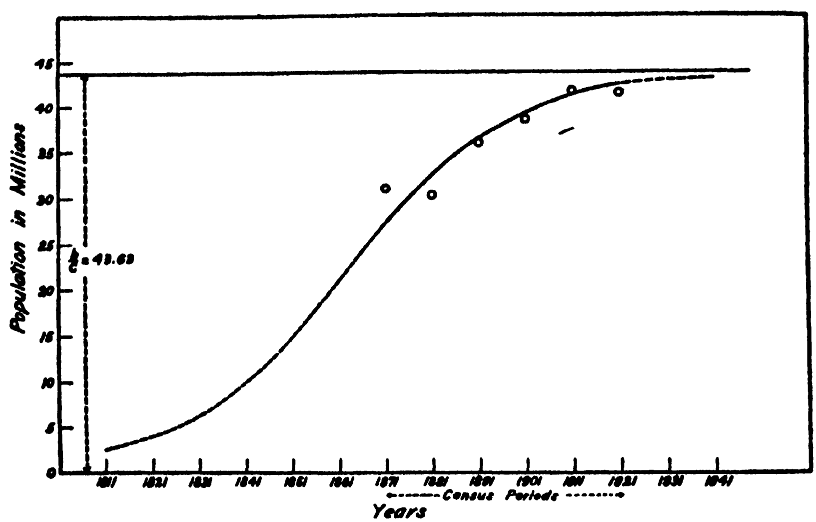

Fig. 1

that the curve shows South India to have very nearly reached an asymptotic population under present conditions. As a matter of fact, it has been necessary during the last few years to import considerable quantities of grain stuffs to meet the needs of the population, and it would appear that in spite of the devastating famine years of 1877–78 and the more terrible influenza epidemic of 1918–19 the population is still too large for the land available with the present futile methods of cultivation. The sociologist might therefore speculate as to the justification for expenditure on public health and prevention of disease, when children and adults saved in one year are apt to be hurled into Nirvana the next by some factor like an epidemic demanded by the inexorable and irresistible pressure of the equation $y = \frac{be^{-ax}}{1+ce^{ax}}$! It is worth while drawing attention in this connection to the decreases of population registered at the censuses following the two calamities already mentioned.

Births

The registered birth-rate during 1922 was 30.0 per 1,000, but it is fairly certain that the actual rate is as high as 42.5 per 1,000. Registration in municipal towns is carried out by paid registrars, but, in the rural areas, which comprise a total population of nearly 36 millions as compared with the five millions of townspeople, registration is done by the village officer. This official post, although not a very lucrative one, carries with it a certain status, and still commands respect, although it can not be obtained by ability to pass examinations but descends from father to son as a hereditary function. As, however, the village officer is primarily a revenue official, it may be imagined that the registration of vital statistics has to take a back seat in the theater of his activities. *In Madras City, where registration is more or less accurately performed, the birth-rate for 1922 was 41.2. The highest* rates are usually met with in Mohammedan communities. During 1922, out of a total of 215 towns, 13 registered a birth-rate of 40 to 50 per 1,000, and six returned the amazingly high rate of over 50 per 1,000.

Deaths

The registered death-rate for 1922 was only 21 per 1,000, but the actual rate was probably in the vicinity of 33 to 36 per 1,000, although the margin of error is not so great as in the case of the birth-rate. The Mohammedan community again returns the highest rate, as they are, generally speaking, a backward people and entirely governed by tradition. In Madras City the death-rate in 1922 was 43.1 per 1,000, whilst in another town, owing to a severe outbreak of plague, the rate was as high as 70 per 1,000. Infantile mortality is very high all over the Presidency, although examination of the registered rates since 1901 shows that there has been a distinct downward tendency during the last 22 years. This fact is of some importance, as a few enthusiasts of the newly fledged child welfare schemes have claimed the reduction in infant mortality to be entirely due to their efforts. Whilst admitting the value of such welfare work, it seems equally desirable to avoid undue optimism as to the results yet obtained. In several of the largest towns the infant death-rates in 1922 ran between 311.6 and 352.8 per 1,000 births, as compared with the English rate of 80 per 1,000. Nearly 50 per cent. of these infant deaths took place during the first month of life, a sad commentary on the condition of the mothers and the degree of skill possessed by the Indian midwife. Generally speaking, the death-rates increase as one goes down the social scale, and although, for example, the infant mortality rate

among Hindus in Madras City taken as a whole is about 300 per 1,000 births, yet the death-rate among Brahman babies is little over 100 per 1,000 births and is nearly as low as that of the European community. As regards maternal deaths, in the towns 13.7 mothers die per 1,000 births, and the rate for the whole Presidency is probably much higher. Indian women, during parturition, are cursed with the attentions of attendants known as "barber" midwives, whose ignorance of antiseptics and their use is as colossal as their courage in tackling emergencies with the aid of collections of the most fearsome and medieval weapons; and every medical man in India is only too well acquainted with the victims of their prowess, brought as they are to *hospital in the last stages of septic poisoning. The prejudices of even the* better educated Indians are almost impossible to overcome, and an example can be given of an educated lawyer, the chairman of a municipality, who had been persuaded to engage a trained midwife for his town, but who declined to employ her skilled services in preference to the barber-woman when his own daughter was about to present him with his first grandchild.

Vital Index

For the whole population the vital index (= 100 births/deaths) in 1922 was 143.3, that for the Hindus being 142.4, for the Mohammedans 151.9 and for Indian Christians 150.8. Comparing the

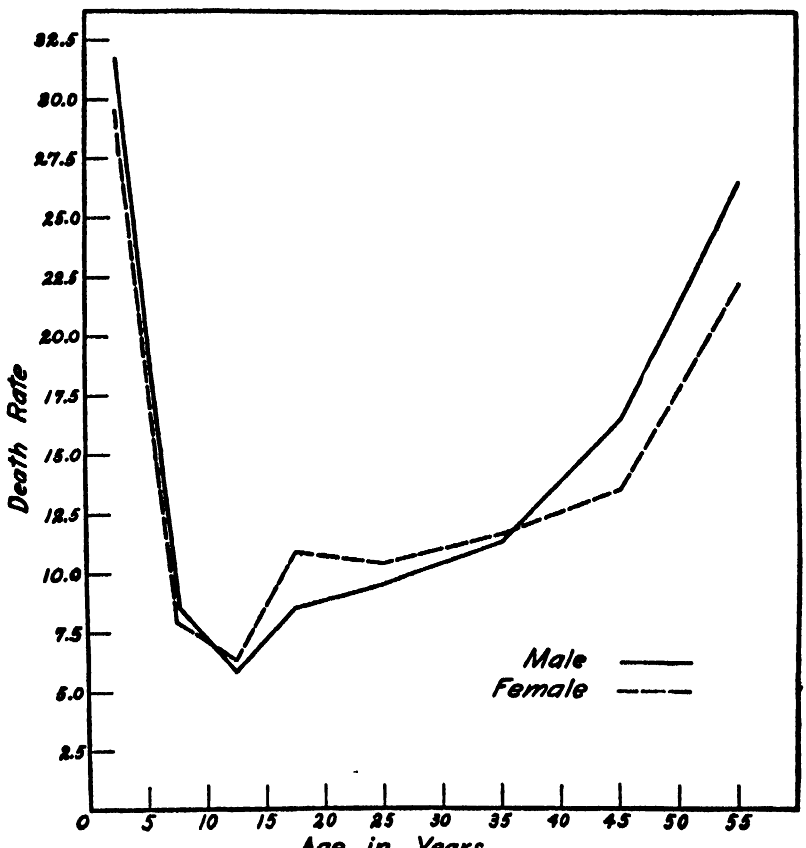

Fig. 2

urban population with the rural, the vital index for the former during 1922 was 122.6, and for the latter 147.6. For Madras City the corresponding figure was only 95.6, in spite of the constant immigration of young adults into the town; and for some of the other large towns the index was also under 100. City life in the Orient is therefore even more fatal to the population than it is in Occidental countries.

A graph showing the specific death-rate curves for males and females during 1922 has been prepared in a very approximate fashion, but it shows the salient points fairly clearly. (Fig. 2.) The most striking feature is the extraordinary hump in the female curve at the age-period 15 to 20 years, and continuing to lesser degree into the period 20 to 30 years. This peculiarity is almost wholly due to maternal deaths, for it is by no means uncommon for girls to be mothers by the age of 13 to 15 years. Calculated on the total female population in the age-periods from 15 to 40 years, the excess death-rate represents approximately 20,000 deaths. To put it in another way, the ratio of deaths in females to every 100 male deaths in the population at different ages is as follows:

	5 to 10	10 to 15	15 to 20	20 to 30
Madras	100	100	117	116
Punjab	113	138	133	125

The figures for the Punjab indicate that the Madras rates are by no means the highest to be met with in India.

For the whole population, the approximate mean duration of life is 27.6 years, as compared with over 45 years in England and Wales in the period 1901–1910.

Chief Diseases

The registrars have instructions to register all deaths under one of the heads referred to in the table, with the exception of "injuries," which are classified into (1) suicides, (2) wounds and accidents, (3) snakebites and death by wild beasts, and (4) rabies; and "childbirth deaths." It is hardly necessary to explain that further differentiation would simply defeat the end in view. Even as it is, many of the village officers make up their registers only once a month, when a return is required, and they allow their imaginations to run riot, or to lie absolutely dormant, when they come to fill in the column of "causes of death." In one district where malaria was the commonest disease, more than 95 per cent. of the deaths were being registered as "fevers." Investigation of 399 deaths in the area showed that only 117 of these were really due to one or other form of fever; 75 were due to pneumonia, consumption and other respiratory diseases—all having fever as a symptom; 50 were due to dysentery and diarrhoea—which may be accompaniments of malaria; 21 were maternal deaths—which certainly all had fever; 4 were due to smallpox, a disease which every attempt is made to conceal; 4 were deaths from accidents such as drowning; 14 were cases of beri-beri and dropsy, and 3 were the result of rheumatism. A village officer, on being asked for an explanation of this carelessness, naïvely replied that it was *"mamool,"* or custom, to register deaths as due to fever, and any one acquainted with India will appreciate the force of "mamool" on the mind of the average Indian.

Chief Diseases

	Deaths in 1922	*Deaths in 1921*
Cholera	16,502	27,064
Smallpox	22,801	9,792
Plague	9,193	11,875
Fevers	319,688	316,019
Respiratory diseases	48,166	45,180
Dysentery and diarrhoea	51,805	53,621
Other causes	391,081	363,346
Total	859,236	826,897

Table II

Cholera

This disease is endemic in India and is one of the greatest scourges of the country. Recent research has shown that the disease not only shows a yearly periodicity, but that in Madras Presidency, at least, there is a definite six-yearly periodic wave. As the usual water supply for the Indian village community is a shallow well, it is not easy to prevent the spread of cholera infection; but chlorination of the wells has given promising results. The villager, however, often resents the introduction of such things as chlorine or potassium permanganate into his water supply, and the sanitary inspector who attempts to do so occasionally finds himself in trouble.

Smallpox

This is another disease which is always to be met with. During 1922, 7,690 deaths from smallpox occurred among infants under one year of age, 8,476 between the ages of one and ten years, and 6,635 above 10 years. Smallpox is therefore still a disease of young children in Madras. The chief reason for this is that the benign British Government has refrained, unlike the more ruthless but more efficient administration in Germany, from enforcing compulsory vaccination on an unwilling but ignorant people. Madras, however, possesses a Vaccine Institute which issues over two million doses of lymph annually. The vaccine is sent out by post, but as it very often takes 5 to 7 days to reach its destination and as the temperature is frequently above 100° F. in the shade, it is difficult to ensure the potency of the lymph by the time it comes to be used. For the same reason, the manufacture of lymph is entirely suspended during the hot weather months, and no vaccination operations are performed during the four hottest months. When this plan was introduced, there was a very considerable reduction in the number of vaccination operations performed, but a corresponding rise in the success rate resulted, which for all practical purposes gave the same number of protected persons, whilst also reducing enormously the labor and cost involved in carrying out thousands of unsuccessful operations. In the more remote districts the cost per vaccination operation may be as much as 50 cents.

Plague

Bubonic plague has been endemic in India since 1896, but in Madras Presidency it has been confined to only seven or eight of the 26 districts which go to make up the province. Occasionally a sporadic outburst of the more fatal pneumonic type of the disease occurs, but these have fortunately never spread beyond a few families at any one time, and there has been no experience of this type of plague corresponding to the epidemics in Korea and North China. The two chief preventive measures adopted are inoculation and evacuation of infected houses. It can be realized that it is by no means easy to evacuate a town of any size, although the fear of plague is now engrained into the Indian and he does not usually raise as much objection as he does to inoculation, owing to the general belief that the latter causes sterility. The plague regulations, issued under the epidemic diseases act, give wide powers to the authorities, who can insist that any one objecting to leave his house shall submit himself and his family to inoculation with anti-plague vaccine. In one badly infected district in 1922 over 95 per cent. of the total population in the affected area were inoculated, but this was an exceptionally successful effort. In one family a man and his wife and children were all inoculated, with the exception of the eldest son, and no powers of persuasion were of any avail in getting permission to protect the boy. Two weeks later infected rats were found

in the house, and the only member of the family who became infected was the uninoculated boy, who eventually died of the disease. A curious fact worth mentioning in this connection is that the Plague Research Commission has found that the best rats for experimental purposes are the rats of Madras City, as these animals are the most susceptible of any Indian rat obtainable. Yet, plague has never managed to retain a foothold in Madras, although sporadic cases have been introduced on many occasions. It is certain that we do not yet know all about the epidemiology of plague in India.

Fevers

Malaria is the predominant fever and almost entirely masks such diseases as typhoid fever and tuberculosis. Typhoid fever seems to be increasing, the figures for the Madras General Hospital being 79 cases in 1910, 706 in 1920 and 564 in 1922, although this may be partly explained by better diagnosis. As regards tuberculosis it was commonly said not to exist in India about twenty years ago, but it is now widespread and a recent estimate puts the figure for Madras City as high as 40,000 cases. A violent epidemic of relapsing fever broke out in Southern India in 1920, and has spread all over the Presidency within the last three years. The disease was entirely confined to the lower classes, and even where caste Brahmans lived in a street surrounded by non-caste people, the houses of the two being only a few feet apart, the communistic segregation practiced by the Brahman acted as a perfect safeguard against infection which was carried by the louse, ubiquitous among the pariahs. Relapsing fever had not been known in South India for over 100 years, and it is tolerably certain that the infection was brought in by troops and followers returning from Mesopotomia and East Africa. Other fevers, such as dengue, 3-day and 7-day fevers, are all very common.

Dysentery and Diarrhoea

Dysentery takes a large toll yearly in Southern India, the disease being mostly bacillary in type. The death-rate in Madras City for 1922 from this cause was 8.0 per 1,000, and in urban areas it varies between 3.0 and 6.5 per 1,000. For statistical purposes, diarrhoea deaths are classed along with those from dysentery, as many of the diarrhoeas are known to be dysenteric in origin. With the decrease which has occurred in cholera during the last six years there has been a corresponding decrease in the number of deaths registered under the term "dysentery and diarrhoea." It is probable that this is due not only to the greater prevalence of diarrhoeal complaints during a cholera epidemic but also to the concealment of cholera cases in order to avoid the worry caused by the visits of officials of the Public Health Department.

Rabies

Rabies is commonly spread by rabid jackals and hyenas. During 1922, 220 deaths from this cause were registered, but doubtless this is an under-estimate. The Pasteur Institute now dispatches the vaccine to all headquarter hospitals on indent, but this method of treatment is open to objection as it is difficult to keep trace of the individual if he chooses not to return before his course of injections is completed.

Ankylostomiasis

Hookworm infection ranges about 100 per cent. in a number of the wet districts of the Presidency, but Dr. Kendrick, of the Rockefeller Foundation, who spent three years in South India, found that in no district was the infection rate under 30 per cent. A survey of the students in the Madras Medical College showed that even in this class of the population the infection rate was from 65 to 84 per cent. In so far as the Rockefeller Foundation plays the part

of a health propaganda agency it has a very important work in hand; but most people will agree that a dozen Rockefeller Foundations could not eradicate the hookworm from the tropics, until the people themselves give evidence of a real interest in health matters, and of that there is so far little sign.

Deficiency Diseases

Some of the deficiency diseases have already been mentioned, but it is worthy of mention that beri-beri is almost strictly confined to a group of districts in the northeast of the Presidency. In the center of this epidemic area, nearly 8 per cent. of the total deaths during 1922 were said to be due to this cause, but this figure no doubt included all cases presenting dropsy as a symptom.

Leprosy

It is estimated that there are over 20,000 lepers in South India, and only a small percentage of those are cared for in leper asylums. The Government of Madras has recently founded a large leper colony, which is to be managed by European missionaries.

Kala-Azar

This puzzling disease finds an endemic home in parts of Madras City and in some of the eastern coast districts. It has never been the serious problem that it has proved to be in Assam.

Public Health Organization

The portfolio of medicine and public health is held by an Indian minister under the Reforms Act of 1919, in which year a number of subjects were transferred to Indian administration. A public health board acts as an advisory body to the minister, and all large schemes, such as water supplies, drainage and sewage works, come before this body for final approval. The public health department proper consists of a director of public health and six assistant directors, while for each of the 26 districts a fully trained health officer is in charge of health activities. Seventy-five per cent. of the salaries of these health officers is paid by the Madras Government, the balance being met from district board funds. In addition, 12 to 14 of the larger towns have full-time health officers of their own. The government also maintains a body of 162 trained sanitary inspectors, 8 to 12 working in each district under the jurisdiction of the district health officer, and a number of trained sanitary inspectors are employed in every municipality. Vaccinators trained in the Institute of Preventive Medicine are maintained by municipal councils and district boards, while registrars of births and deaths are attached to all municipal health staffs. The total municipal expenditure on public health during 1922 amounted to 23.5 lakhs, or about $800,000. The corresponding expenditure of local boards was 10 lakhs or about $340,000, whilst government expenditure on public health amounted to 30 lakhs or about $1,000,000. The total cost works out at nearly 1.3 annas, or about 2 cents, per head of the population. Before making any invidious comparison of this figure with those of other countries, it must be remembered that India is a poor country, the total budget of the Government of India being only something like five million pounds sterling, or less than $25,000,000.

For the furtherance of public health in the Presidency, a Madras Health Council has recently been inaugurated. Its chief function is the distribution of health propaganda literature and illustrated health lectures, and from its first annual report, which has just been published, it is obvious that the council has met an urgent need. The Madras Maternity and Child Welfare Association has

18 centers in Madras City, and also 15 to 20 others in different towns in the Presidency. The Ankylostomiasis Bureau, *staffed by the Rockefeller Foundation, acts as an additional agency for the spreading of knowledge of hygiene and public health. It is to be remembered* that every leaflet, every poster and every lantern slide and lecture must be prepared in four to six different vernacular languages if they are to be fully effective, and this adds enormously to the cost of a propaganda campaign.

Finally, as regards legislative measures dealing with public health, either partly or wholly, these constitute quite a formidable list. The "Madras City Municipal Act" applies only to that city, the corresponding measure for other towns being the "District Municipalities Act," while for rural areas the "Local Boards Act" includes a number of sections on public health. Additional measures are the "Village Panchayat Act," the "Town Planning Act," the "Indian Factories Act," the "Registration of Births and Deaths Act," the "Town Nuisances Act," the "Epidemic Diseases Act," the "Foods and Drugs Act" (for prevention of adulteration), and the "Indian Ports Amendment Act," which deals with port sanitation and marine quarantine. Most of these acts are local acts passed by the Madras Legislative Council, but the "Epidemic Diseases Act" and the "Indian Ports Act" are Imperial, and apply equally to the whole of India.

Under the municipal and local boards acts *a volume of model by-laws has recently been prepared and issued by the government for the guidance of bodies* concerned in local self-government. The health officers employed in Madras are trained in the medical college and must possess the degree of "Bachelor of Sanitary Science" of Madras University before they are confirmed in their appointments. This degree is based on the regulations in force for the "Diploma in Public Health" of British universities. All sanitary inspectors are also trained in the medical college, where they undergo one year's course in various subjects preparatory to taking a government examination for the "Sanitary Inspectors' Certificate." Every five years each sanitary inspector is required to take a refresher course and pass a further examination.

Certain individuals, ignorant of local conditions, are apt to be hypercritical of British administration in India, because of the apparently slow advance made in such fields as that of public health, but it must be fairly obvious to the unbiased mind that a sound organization is in existence, in Southern India at least, and it remains to be seen whether further progress will be made now that the helm of the Ship of State is passing into the hands of Indians themselves.

THE PRESENT STATUS OF THE THEORY OF RELATIVITY[1]

By Dr. PAUL R. HEYL
BUREAU OF STANDARDS

In the realm of science, as well as in that of sport and adventure, there is to be found the excitement that arises from the unexpected. The present status of the theory of relativity is a case in point. In its unexpected advent and its rapid rise to first magnitude it suggested a new star; but it has been no longer ago than the Toronto meeting of the British Association in 1924 that the opinion was expressed by a leading authority that relativity had reached its maximum, had "struck twelve" and become barren. Many of us can remember a similar feeling of pessimism regarding physics in general which possessed the minds of scientific men for several years just prior to the discovery of the X-rays. It was widely held that the great discoveries in physics had all been made, at any rate, all that were possible, and that future progress would concern itself with second order effects and "one more decimal place."

There was much, indeed, to warrant the opinion that the theory of relativity had achieved the status of a classic and was henceforth to be comfortably shelved alongside the Principia; yet while these opinions were being expressed, experiments were under way which, when announced in the spring of 1925, injected new life into the theory of relativity and created a situation of which the end is not in sight. We refer, of course, to the repetition by D. C. Miller of the historic Michelson-Morley experiment on the top of Mt. Wilson and his announcement of a definitely positive result.

It has perhaps been rather generally supposed that the theory of relativity arose from a negligibly small result obtained when this experiment was originally performed by Michelson and Morley in the attempt to find evidence of the supposed motion of the earth relative to the ether. This is only part of the truth. There were other experiments, all to the same purpose and all yielding negative results. It was the cumulative testimony of all these which led Einstein to formulate his theory of relativity.

Such an experiment was that performed by Trouton and Noble,[2] first suggested by Fitzgerald.[3] It appears from theoretical considerations that a condenser, suspended by a fine filament with its plates inclined to the direction of the ether-drift should, upon being charged, experience a torque. Trouton and Noble tried this experiment, obtaining a negative result.

Another experiment of this kind aimed at the detection of double refraction produced in a transparent body on account of ether-drift through it. It is a natural conclusion that if the ether be streaming through a block of glass in a certain direction the speed of light in this direction will be different from that at right angles to it. The block of glass for this reason should become doubly refracting. Experiments of this nature

[1] Published by permission of the director of the National Bureau of Standards of the U. S. Department of Commerce.

[2] Phil. Trans. A, Vol. 202, p. 165, 1903.

[3] Scientific writings of G. F. Fitzgerald, p. 557.

were performed by Rayleigh[4] and by Brace[5] with negative results.

These experiments are so simple in theory and parallel so closely the well-known work of Fizeau on the speed of light in moving water (which, however, gave a positive result) that they are worthy of careful study. If there is any such thing as ether-drift in a transparent body it would appear impossible to have an optically isotropic body at all, unless its natural double refraction happened to be equal and opposite to that produced by ether-drift; and this could be discovered by observations made in different orientations of the whole apparatus with respect to the earth's motion in space.

These various lines of experiment were known to Einstein, and his special theory of relativity was a generalization resulting from a view of the entire field of evidence. For some reason, however, it appears that the Michelson-Morley experiment has, in the minds of many, gradually come to be credited with the sole responsibility for the origin of the theory of relativity, and the recent announcement by Professor Miller has, perhaps, created a rather general impression that "relativity is dead."

But before we can come to such a conclusion it will be necessary to see what results will be furnished by the other foundation experiments of relativity, the Trouton-Noble and the Rayleigh-Brace experiments when performed at a considerable altitude. Attention was called to this necessity in a note[6] published shortly after Miller's first public announcement.

It is with special interest, therefore, that we learn that Professor Tomaschek, of Heidelberg, has repeated the Trouton-Noble experiment on the Jungfrau, at an altitude twice that of Mt. Wilson, with a negative result.[7]

[4] *Phil. Mag.*, December, 1902, p. 678.

[5] *Phil. Mag.*, April, 1904, p. 317.

[6] Heyl, "The Ether Drift," *Science*, May 15, 1925.

[7] Annalen der Physik, No. 24, 1925, p. 743.

Tomaschek has done more than merely to repeat the experiment as Trouton and Noble carried it out. He has executed a variation upon it by searching for the production of the magnetic field which should be produced in the neighborhood of a charged condenser moving with a velocity relative to the surrounding ether. This variation has one great advantage: the effect it deals with is of the first order, while that of the original Trouton-Noble experiment (and also the Michelson-Morley experiment) is of the second order.

Tomaschek's experiment appears to have been most carefully executed, yet attention may be directed to one point. It has been shown by Kennard[8] that the theory of the Trouton-Noble experiment, as originally carried out with a mica condenser, is still somewhat uncertain. Kennard advised future experimenters to use an air condenser, the theory of which is satisfactory. Now it appears that in Tomaschek's repetition of the Trouton-Noble experiment a mica condenser was used.

Fortunately, however, in the variation of this experiment carried out by Tomaschek an air condenser was used for some of the experiments. In others, a dielectric of sulphur was employed which, being a crystalline body, Kennard would regard as unsuitable.

Tomaschek's closing discussion is admirably judicial. He recognizes the conflict between his result and that of Miller, and points out the advisability of a repetition of one of the experiments at the same place in which the other was performed. To this may be added the obvious suggestion that it would be an additional source of security and satisfaction to have these experiments carried out by independent observers, provided it is possible to obtain such equally as skilled as Tomaschek and Miller.

In the new interest now attaching to the special theory of relativity the ex-

[8] Bulletin of the National Research Council, No. 24, Vol. 4, part 6, December, 1922.

periments of Rayleigh and Brace should not be overlooked. Their theory is very simple, and the necessary instrumental outfit ought not to be incapable of being so constructed that it may be carried up in an airplane.

We have made as yet no reference to the three experimental tests of relativity suggested originally by Einstein, for the reason that none of them refers to the special theory of relativity, which is the aspect of the situation now brought anew into question by the results of Tomaschek and Miller. Einstein's three tests are concerned with the general theory of relativity, or, more specifically, with Einstein's theory of gravitation. It is to be remembered that the general theory of relativity is founded upon a postulate not involved in the special theory—the equivalence of gravitation and inertia—and that if the special theory were to be finally discredited this principle of equivalence would remain unshaken.

It is therefore a source of satisfaction to turn from the contradictory and confusing evidence in the case of the special theory of relativity and find that the evidence for Einstein's theory of gravitation is consistent throughout.

Three tests for this theory were originally suggested by Einstein: the irregularity in the motion of the planet Mercury; a deflection of light rays passing near the sun; and a shift of the Fraunhofer lines in the solar spectrum.

Of these three the first was the earliest to establish itself, albeit not without opposition. There were not lacking attempts to explain this anomalous motion by postulating the existence of attracting matter between Mercury and the sun, but the difficulty was to account for the disturbance of Mercury without interfering with the motion of Venus. The seriousness with which the anomalous motion of Mercury has been generally regarded and the impossibility of accounting for it by the law of gravitation are shown by the fact that at one time the radical proposal was made to alter slightly the Newtonian formula by changing the exponent 2 to 2.000 000 1612. This was first suggested by the elder Asaph Hall, the discoverer of the satellites of Mars, and was for a time regarded favorably by no less an authority than Newcomb, who abandoned it only after E. W. Brown showed that the motion of the moon did not allow of even this slight departure from the number 2. But with the ease and grace of a master, Einstein shows how it is possible to account for the irregularity of Mercury without altering the relations between the earth and the moon, or disturbing the motion of Venus or any other planet. In default of any other theory, the relativistic explanation of the motion of Mercury has attained an acceptance which, though perhaps provisional, is general.

In his second and third proposed tests Einstein ventured upon dangerous ground—that of prediction. Here it was no longer a question of explaining a known fact, but of predicting something which had not yet been observed or even suspected. The success of such a prediction has always been regarded as a weighty argument for the theory in question; for example, Poisson's prediction of the existence of a bright central spot in the shadow of a circular disc did much to establish the undulatory theory of light.

For the experimental confirmation of the second test, the deflection of a light ray grazing the sun's surface, it was necessary to wait for a total eclipse. Two such opportunities presented themselves within a reasonable time, and finally (largely as a result of the Lick Observatory expedition to observe the eclipse of 1922) Einstein's prediction was accurately confirmed.

The third test has been much more difficult to confirm than either of the first

two, because of its small magnitude. The shift of the solar lines predicted by Einstein is an amount so small as to be difficult to detect in the presence of other displacements which have long been recognized and understood. Contradictory results were announced by several observers, and much uncertainty existed until Adams, of the Mt. Wilson Observatory, succeeded in the difficult task of photographing the spectrum of the faint companion of Sirius. The advantage of using the spectrum of this star rather than that of the sun is the vastly greater gravitative field obtainable, and the consequent multiplication of the Einstein shift.

The companion of Sirius is one of the most remarkable stars in the heavens. It was discovered in 1862 by Alvan G. Clark, while testing a telescopic objective. It is a very faint star, of about one ten thousandth the brightness of Sirius. Its mass is about equal to that of our sun. Its spectrum is of such a nature as to indicate a surface temperature of about 8,000°; that of the sun is 6,000°. Its brightness per unit surface must therefore be greater than that of the sun, though the total light it emits is considerably less. It must in consequence have a smaller surface (and diameter) than the sun, though equal to it in mass; in other words, it must be of a much greater density.

Upon calculation, its density comes out so high as to appear at first sight preposterous. Eddington[9] finds it to be about 50,000.

That a body of such unheard-of density can obey the gas laws is at first sight impossible; yet Eddington offers the ingenious and plausible suggestion that the atoms of the star, at the very high temperatures prevailing in its interior, may have their electrons knocked off, leaving the nuclei only, which, deprived of their "crinoline" (as Sir Alfred Ewing calls it), may pack far more closely than before and yet be sufficiently distant to correspond to a gaseous structure.

At the surface of a star of this density and of a mass equal to that of our sun, the solar Einstein shift would be multiplied some thirty-fold, placing it well within experimental recognition. The shift actually found by Adams is within ten per cent. of that calculated by Eddington.

Considering the approximate nature of Eddington's calculated value of the density, this is a confirmation of the third Einstein test that is entirely satisfactory.

A fourth experiment, proposed to test the fundamental postulate of Einstein's gravitational theory, was carried out a few years ago at the Bureau of Standards.[10] This theory is, as has been said, based upon the assumption of the identity of gravitation and inertia.[11] A delicate test of this postulate is possible with a crystal of one of the non-isometric systems, for in such a crystal every known physical property (save inertia and, possibly, weight) varies with the axial direction in the crystal. The speed of light in such a crystal is different in the different axial directions, making the crystal doubly refracting; the conductivity for heat and for electricity vary similarly; the coefficient of expansion, the elastic modulus, the selective absorption for light, the pyro-electric and piezo-electric properties (when present), and even the hardness of the different faces all vary with the axial di-

[9] Monthly Notices, Roy. Ast. Soc., March, 1924, p. 322.

[10] "Scientific Papers of the Bureau of Standards," No. 482, February 16, 1924; "Gravitational Anisotropy in Crystals," Heyl.

[11] Heyl, "The Common Sense of the Theory of Relativity," SCIENTIFIC MONTHLY, December, 1923.

ration involved. It is therefore an interesting question whether in such a crystal gravitation will behave as do the overwhelming majority of physical properties, or whether it will align itself with inertia, standing alone on the other side.

The possibility that crystals may display gravitational anisotropy has not gone unrecognized. All previous experimental work on the subject, however, antedates Einstein, and the results were uniformly negative. No great degree of precision was reached, the highest being that of Poynting and Gray,[12] one part in 16,000, not at all an adequate answer for a question of this importance. Moreover, all such work was confined to crystals of the hexagonal system.

The experiments at the Bureau of Standards were planned to include specimens of all non-isometric crystal systems, and to reach as high a precision as possible. The method was that of direct comparison of weights in different orientations of the crystals with respect to the earth. The precision reached was one part in a billion (10^9) and to this degree no difference in weight was observable.

A fifth experiment, suggested by Silberstein[13] and executed by Michelson, is of interest in this connection. It was based upon the possibility of the rotation of the earth having an effect upon the speed of light. If the ether rotates with the earth there can be no acceleration or retardation of a beam of light traveling in any direction on the earth's surface; but if there is any differential motion between the earth and the ether it should be possible to show it by sending two beams of light in opposite directions around a closed circuit, and looking for a shift of interference fringes. Silberstein also calculated from the general relativity theory, without any reference to an ether, that a shift of interference fringes should also result, equal in magnitude to the maximum produced by a completely stagnant ether.

Hence, if it should be found that there is either no shift, or a shift less than the maximum, relativity would be wrong. A maximum shift, however, would be ambiguous; either relativity is right, or there is an ether which does not partake at all of the earth's rotation. This ambiguous result was actually that found by Michelson.

This result, while indefinite as far as relativity is concerned, is rather in conflict with the original Michelson-Morley result (at ground level), though it may be said, of course, that ether drag due to rotation and to translation may be two different questions. No reason, however, is apparent for drawing such a distinction.

What, then, is the present experimental status of the theory of relativity?

The evidence in the case of the special theory is conflicting. The experiments of Tomaschek, the original Trouton-Noble experiment (for what it may be worth), the experiments of Rayleigh and Brace, and the original Michelson-Morley experiment (near ground level) all point to the non-existence of ether-drift. It should be noted, however, that Miller emphasizes the point that the original results of the Michelson-Morley experiment were in no case zero, but only a very small fraction of that expected. Miller's later result points to an ether-drift of considerable magnitude, ample enough to be easily detected, it would seem, by any of the other experiments. Further work, involving interchange of stations and variations of observers, is called for.

With the general theory the evidence is entirely concordant, with the exception of one result, which is ambiguous.

[12] Phil. Trans. Roy. Soc., Vol. 192, 1899, p. 245.

[13] *Phil. Mag.*, September, 1924, p. 395.

Additional weight perhaps attaches to the positive results of two of these experiments from the fact that those in charge of the work had no previous bias in Einstein's favor. This was the case with the Lick Observatory eclipse expedition, in charge of Director Campbell, and with the crystal weighing experiments at the Bureau of Standards. The latter work was indeed undertaken by the experimenter in a spirit of definite skepticism regarding Einstein's theory, which appeared (to one who had learned his physics before the discovery of the X-rays) rather too bizarre and fantastic. But the negative result of this work placed the experimenter very much in the same position as that in which Balak, the king of the Moabites, found himself on a certain occasion.

The land of Moab had been invaded by the host of Israel, as the sands of the sea in number. A battle was impending, and Balak was none too certain of the outcome. He felt that he needed moral support and ghostly counsel, and he sent messengers to Balaam the soothsayer, saying: "Come, curse me Jacob; come, defy me Israel!"

It was a professional call, and Balaam came. Balak was glad to see him. He gave him presents; he showed him much honor; he took him up to a high place where he might see the host of Israel encamped on the plain below, and he waited impatiently for the soothsayer to speak.

And Balaam spoke the words which the Lord put into his mouth; but Balak looked at him aghast, and said: "What is this? I called thee to curse mine enemies, and lo! thou hast blessed them altogether!"

RADIO TALKS ON SCIENCE[1]

HUMAN NATURE AND WAR

By Professor GEORGE M. STRATTON
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Of the Four Horsemen described in the Apocalypse, science gives us high hope that at least two can be unhorsed. By our increasing medical knowledge, we are gradually ridding the world of pestilence; and there is reason to believe that science will rid the world of famine. But with regard to war there are many who assert that science offers no hope whatever; that it indeed closes the door against hope and leaves us to despair.

For war, it is said, springs from human nature; and will continue as long as our unchanging human nature lasts.

No statement which claims the authority of science could be of greater importance to the public. It touches national interest and international policy at every point. Psychology could not be of greater service than by helping toward an intelligent decision of so weighty a problem. With your consent and interest, then, let us face this single question steadily. Is it true or is it not true that our increasing knowledge of the human mind shows that human nature will always require nations to settle their disputes by physical violence rather than by law and its more orderly methods? The true answer to this is worth untiring search.

Those who declare that war comes from human nature and that human nature does not change have weighty evidence for their belief. Wars have occurred since the remotest time of human history. Wars doubtless were waged long before human history began. They reach still farther back, into the animal world, where pugnacity is frequent and widespread. Thus all the momentum of our animal and human inheritance would seem to carry us fatally forward along the ways of war. It surely seems that humanity is pugnacious in its very nerve and muscle; that man is born to battle as the sparks fly upward. Human nature through all the ages, it would seem, shows the same qualities, and will prevent change, whatever may be the strong desire for a different order of life.

And yet the thought which I would urge as the word of science is the exact opposite of this. I shall ask you to observe for yourselves profound changes which have occurred in human society and which have not required a shadow of turning in human nature itself—changes quite as profound as would be involved in driving war to the very outskirts of society. Institutions based upon the most permanent traits of human character have been torn down and swept away, and without destroying or even weakening a single one of our great human motives.

II

Would you be willing to go with me, not back to the cave man, but to what has occurred within comparatively recent times—in Mexico, in the islands of the Pacific and in Africa? In these and in other places it was customary to sacrifice living men upon the altar of some powerful supernatural being. To obtain the creatures for such sacrifices was often one of the aims of war. And beyond this, it was thought that the divine wrath could be appeased, not by sacri-

[1] Broadcast from Station WCAP, Washington, D. C., under the auspices of the National Research Council and Science Service and the direction of W. E. Tisdale.

ficing war prisoners only but by sacrificing the life of one's own son or daughter, by thus offering something still more precious to the worshipper and to his god.

We can imagine the opposition to those who in due time wished to do away with this ghastly institution. "What!" others must have said, "Would you change human nature? Do you expect men to give up their very religion? Would you have us refuse to offer to our divinity the most precious things we have?" And yet in spite of such misgivings human sacrifice in all civilized regions has gone forever, and without altering a single one of the deep motives which supported it. There remained unchanged the love of children; indeed this love grew stronger; and there grew stronger also the sense of the value of human life generally. There remained the same awe of the unseen world and the same impulse to avert the wrath of this unseen world. The institution of human sacrifice was destroyed without changing human nature and without destroying either religion or human dedication to the ideal.

And the same is true in another great region of social conduct. Blood vengeance once existed almost the world over—the feeling that the death of a member of one's own family must be avenged by taking a life of the family that caused the death. The impulse to wreak such vengeance has been exceedingly powerful and exceedingly difficult to control. Even so mild a statesman as Confucius felt that an official could not live in the same country with one who had killed a high officer of the state. Confucius felt that any subordinate official must personally see to it that the death of his superior did not remain unavenged.

But there came a time when the spirit of the law spoke with an entirely different voice. It said "No" to this deep and almost irresistible cry that an individual who has been wronged shall himself take the blood of the wrong-doer. "Vengeance is mine," the law came finally to say, "and not yours." "Your impulse is, in a measure, just; but it is a too-crude, a too-expensive way to obtain justice. There will, on the whole, be more of justice if those who are less close to the wrong shall determine who is guilty and what shall be his punishment." Here, again, we may imagine the critics who in that day exclaimed: "Do you expect a man not to burn with indignation at the death of his own kinsman? Is he to accept coolly the killing of his father or of his son? You will first have to change human nature before you can attain your goal." Yet in spite of the seeming inability, the institution of private blood-vengeance has been done away, and without requiring that human nature should change by a hair's breadth. There still remain all the deep motives of revenge. There is in us to-day the same love of family, the same hatred and rage at the taking away of one's own flesh and blood, the same desire to right the wrong done by the violator of the family tie. Personal blood-revenge has given way to communal law without requiring that human nature itself should give way. We simply have instituted better methods of satisfying the ancient human impulses, while leaving the impulses themselves strong and untouched. In the same way one might speak of piracy and of duelling, which also have been virtually abolished while human nature remains unchanged.

But I hasten on to slavery, which comes closer to us and whose abolition is within the memory of men who still live. Slavery's hold upon man is from earliest times. The enslavement of others has marked the leading people of the world. Civilization itself has seemed impossible without it. Only yesterday the living bodies of men and women were bought and sold even in our own land. Its effect is before all our eyes in the mil-

lions of Negroes now everywhere in our country. What deep psychological roots slavery had! It drew its strength from the acquisitive impulse—from the desire for wealth, for property. It drew its strength also from the joy of dominating other human beings; from the satisfaction which comes of leisure with its opportunity for a more generous giving of necessities and of luxuries to one's own family and to one's friends. Slavery was protected by all the intellectual and the emotional defenses of those who owned slaves. It seemed as though the laws of nature, of society and of God not only supported but required this institution; and as though the men who worked to abolish slavery had no acquaintance with the human mind, of what is possible with human nature.

But when the time came for Lincoln to sign the great Proclamation, did he by so much as a jot or tittle have to annul the laws of human nature itself? No. Men continued as before to be avaricious. They still are ready to use other men for their own interests. They still are ready to believe that what they deeply desire is also deeply right. But society has fixed new limits to the ways in which men can gratify their impulses to acquire wealth and to control their fellows and to seek leisure and luxury. No attempt was made to eradicate the old impulses, but only to set bounds within which these impulses might seek their satisfaction. There has been no general repression; indeed, there has been given a larger opportunity than ever before to acquire wealth and to control one's fellows. Even in the restrictions a larger opportunity was offered to the disappointed impulses. But men have been prohibited from buying and selling men as one buys cattle.

III

Now to turn our attention, in closing, again to war. Is it, in its relation to human nature, essentially different from these other forms of social behavior? War unquestionably is one of the modes in which our nature finds expression. Deep, indeed, is its hold upon us. The worst, the best of us, goes into it. Hardly a strand is there of human life that is not woven into its texture. Hardly an interest is there to which war does not minister. The difficulties of restraining it are immense; those who would change our ways with regard to it have no light task. So long is war's history and so deep its roots that all thoughtful men will have at times some touch of despair that there can be success against it.

And yet I feel sure that such despair is not scientifically justified. The thought that success here is not impossible can be held without forgetting or misrepresenting human nature. It can be held without shutting one's eyes to the plain facts of experience and psychology. It may well be true that in all its large outline human nature does not change. And yet our experience shows that this unchanging nature of ours permits important changes in human conduct. Indeed, under the stimulation of social enterprise, human nature not only permits, but *demands profound changes.*

We can not doubt that humanity will keep the great impulses which still lead to war—among which is the love of wealth, the love of adventure, the love of honor, the love of mother country. Yet there can be a growing impatience, a growing abhorrence of satisfying these great impulses by the old and bloody methods. Nor is there in the science of psychology anything to assure us that in this one region no farther advance is possible; to assure us that here men have reached the last limit of their inventiveness; that they can institute no shrewder and more satisfying devices to express their devotion to their own nation's life and to the life of the world.

And if those who respect science ask, "What of those who assert that human nature is always the same?" The reply with the best light of science must be:

"Yes, they are probably right in this. Within wide limits human nature does not change. Yet they are wholly wrong in supposing that for the end we here have in mind it needs to change." Great things have been done, while human nature has remained the same. Our civilization has been rid of human sacrifice in our civil life, of piracy upon the high seas, of slavery in all the leading communities. Every one of these social institutions has had the support of men's permanent passions, of men's deepest impulses. To rid the world of these crooked ways of conduct, it has not been necessary to rid the world of humanity. Nor has it been necessary to wait until all sinners have been changed to saints. It has been necessary merely that men should be socially progressive, inventive, adventurous. Men have had to cooperate with others untiringly to change the old habits of their social life. New ways of justice and law and order have had to be viewed with hospitality, without a too tenacious clinging to the cruder and less effective ways.

Human nature here plays a double rôle. It runs with the hare and hunts with the hounds. It expresses itself by clinging to the old, by reverting to the old; but it expresses itself no less by dissatisfaction with the old, by progress to the new. It has not stood as a wall against improvement. The advance, the untiring search for more effective institutions of justice, for more effective ways of meeting the rival claims of large groups of men—these changes are an utterance of our nature. The deepest forces behind human conduct do not merely oppose civilization; they also press us to be more and more civilized. Human nature resists progress, but in all leading lands it also gains the victory over its own resistance, over its inertia and habit, over its own conservatism. It gives the motives, the human instruments and leaders, the intelligence, the insistent urging, which in the past have enriched and strengthened our civil life. And these same great forces, psychology in no wise forbids us to hope, will bring nations to establish better institutions than war to do the work of war.

MAKING AIRSHIPS SAFE

By Dr. L. B. TUCKERMAN

DIVISION OF MECHANICS AND SOUND, U. S. BUREAU OF STANDARDS

THE successful polar flights of Byrd in an airplane and of Amundsen in the airship *Norge* are still fresh in our minds. We realize more fully than ever before that the airways of the earth are open, though all other ways are closed. The contrast between these two flights and also Amundsen's partially successful airplane flight of last year show again that for a full mastery of the air both airships and airplanes are necessary, each in its own particular field.

In providing for the future development of aviation in the Navy this fact was recognized. The bill passed recently by the House of Representatives, which is now before the Senate for its consideration, authorizes the construction of two new airships, each of six million cubic feet capacity. These are to be rigid airships, similar in construction to the *Shenandoah* and *Los Angeles*. In view of the probability of the construction of these ships, it seems worth while to discuss some of the provisions made to insure their safety. The Bureau of Standards is by law commissioned to assist the United States Navy and other government departments in their scientific and technical problems. The United States Navy has consistently made the fullest use possible of the facilities af-

forded by the Bureau of Standards and many lines of investigation connected with the safety of airships have been in the past and will be in the future carried out at the Bureau of Standards. The work at the Bureau of Standards is, of course, only a part of the technical investigations which are carried out for the purpose of designing safe airships. Both the U. S. Navy and U. S. Army maintain their own investigational laboratories; the National Advisory Committee for Aeronautics also contributes its share and more particularly serves as a directing agency to coordinate all work of this kind in all branches of the government service. My talk this evening, however, will be confined to the work of the Bureau of Standards, with which I am most familiar.

Safety is a relative term. We make houses safe, and our larger cities have building codes in which are written the lessons learned from years of experience of house building; but nevertheless houses fall. We need merely to remember the earthquakes of Tokyo in Japan and of Santa Barbara in California, the volcanic eruptions of Vesuvius and Mount Pelée or the tornadoes which devastated the cities of Omaha and, more recently, Lorain, to realize that houses can not be made absolutely safe against the gigantic forces of destruction which at times rage on the surface of the earth. No construction of the hand of man is absolutely safe.

For over five thousand years men have sailed the sea in ships and five thousand years of training in seamanship lie behind the safety of our present-day maritime traffic. Two thousand years ago Horace said, "Oak and triple bronze armored the heart of the man who first entrusted a frail bark to the ruthless sea"; and to-day, although we know that our ships are safe, as safe as human skill can make them, still in our litanies we have the prayers "for those in peril on the sea." Fourteen years have passed, but the memory of the *Titanic* is still with us. The loss of over fifteen hundred lives in that one disaster teaches us that these prayers are not mere empty forms. The dream of "a goodly vessel that shall laugh at all disaster and with storm and whirlwind wrestle" is still a dream of the future. None the less do men go down to the sea in ships and each year the toll of life decreases.

For thousands of years man has looked upon the birds of the air and dreamed of the time when he, too, would fly, yet it is but a little over a century and a half since man first took to the air, in the balloons of Montgolfier and Charles. It is a scant quarter of a century since navigation of the air became a reality. There has not yet been time for him to learn all the dangers of the air nor for his skill to defeat them. Much already has been accomplished. In the years before the war the German Zeppelins carried over forty-two thousand passengers in more than two thousand flights, and after the Armistice one airship, the *Bodensee,* carried twenty-five hundred more passengers without a single injury to passengers or crew. Much more, however, remains to be done. The loss of the *R-38,* the *Roma* and finally the *Shenandoah* warns us against overconfidence. Even the Polar flight of the *Norge,* dramatically successful though it was, shows again that only through navigating the air can we learn to make air navigation safe. The danger to airships from ice was learned only by actual flight, and the flight of the *Norge* teaches us that this danger must be considered even more carefully in the future. If, after ten thousand years of building houses and five thousand years of sailing in ships, human lives still are lost in the destruction of these works of man by the forces of nature, we must expect as the price of our conquest of the air a toll of human lives. It is the task of every one connected with the development of airships, physicist, chemist, materials engineer, designer, constructor, navigator, to make that toll as small as possible. All

the resources of science and engineering and the accumulated experience of years in building structures, in navigating ships of the sea, and the still scanty, yet valuable, experience in navigating ships of the air must be brought to bear upon this problem.

So many factors enter into the safety of an airship that in the portion of the problem assigned to the Bureau of Standards nearly every line of activity of the bureau is asked to contribute its share. First, the airship must be built of light, but sound and lasting materials, in particular its rigid framework. For this reason, the Bureau of Standards studies in its metallurgical division and engineering mechanics section the properties of duralumin, how it is affected by heat treatment and working, how well it resists the corrosive influence of the atmosphere. Duralumin (the aluminum alloy of which the *Shenandoah* and *Los Angeles* were built) is to-day, when unprotected, more resistant to atmospheric corrosion, or rusting, than unprotected structural steel, but the investigations of the Bureau of Standards promise to furnish means of making it even more durable. Of these sound materials, strong and light girders must be built. So light that a man can carry one of them in his hand and yet so strong that they will carry loads of thousands of pounds. Not yet do we know how light these girders may be constructed and still be safe, but the safety of the ship is insured by testing each of its main girders in our testing machines so that we know its strength is greater than the strength for which it was designed. For the *Shenandoah* nearly 150 full-sized girders were tested and a similar and larger program is planned for these newer ships.

The lifting of the airship is due to the helium gas confined in the gas cells. The securing of gas cells, light and strong and impermeable, is necessary to the safety of the ship. The strength and the permeability of the gas cells are tested by the textile section and the gas section of the Bureau of Standards, and an active investigation is being carried on to secure even stronger, lighter and more impermeable cells.

The problems of design are the problems of the Bureau of Aeronautics of the Navy Department, but so important is the design of such a ship that they call in consultation qualified men from other government departments to advise them on their problems, and part of the work of the engineers of the Bureau of Standards is to assist them in securing the best and safest designs.

Each ship, when built, becomes a school and though the ships to be constructed will represent the best that can be produced with our present knowledge, in the future airships will be still better. Part of the problem is to study the behavior of these airships in flight so that from it lessons may be learned that will make possible these greater improvements in the future.

The electrical division of the Bureau of Standards has developed an electric elemeter already in use on the *Los Angeles* and to be used in future ships. With these instruments the stresses set up in the structure of the ship in flight will be measured. From the measurements it will be possible to learn where, in future ships, lighter construction may be safely used or where alterations in the design may be made advantageously.

When the ship is flown, it is necessary for its safety that the engines which drive it shall be adequate in power and reliability. The problem of a reliable airship engine is not so simple as that of a reliable automobile engine. Two factors enter into the problem which are of less importance for automobiles. In the first place, lightness of construction is essential far more than in any engine which operates on the ground and, in the second place, it is necessary that the engines operate successfully under extremes of temperature and pressure never encountered by an automobile engine. Those of you who have motored

through the Rocky Mountains know that even relatively small heights interfere considerably with the running of a gasoline engine. An airship engine must not only operate satisfactorily at the temperatures and pressures at the surface of the earth but at temperatures often thirty or forty degrees below zero and pressures less than one third the air pressure at the surface of the earth, found at altitudes of thirty thousand to thirty-five thousand feet. The altitude chamber of the Bureau of Standards is a chamber in which engines can be tested under approximately these conditions. Refrigerating machines lower the temperature and large air pumps exhaust the air so that the engines are run under pressures and temperatures corresponding to altitudes of over thirty thousand feet. All the types of airship engines used by the U. S. Navy have been tested in these chambers before being installed.

The navigation of an airship is very much more complicated than the navigation of a ship on the ocean, involving problems in three instead of two dimensions. So important for their safety is the adequate knowledge of the condition of all parts of the ship that many special instruments have been developed for this purpose. The aeronautic instruments section of the Bureau of Standards has contributed many of these: a fabric tension meter to measure the tension of the outer cover; a superheat meter to measure the temperature of the gas in the cells; a gas pressure alarm to tell when the pressure of the gas has reached its safe limit; a gasoline flow meter to insure an accurate control on the fuel consumption of the engines; for control of navigation the earth inductor compass; an air speed meter; an altimeter to show how high the ship is flying; an electric turn meter and a pitching indicator to show how rapidly the ship is turning to the right or left or up and down; a rate-of-climb meter to indicate how rapidly it is rising or falling; a sextant for observation of the position of the sun and the stars, necessarily more complicated than the common sextant used at sea. These are some illustrations; time will not permit of a complete description of these instruments, but a visit to the control cabin of an airship will show how carefully provision is made to insure that all the conditions of the ship which affect its navigation are measured and controlled, by instruments immediately under the eye of the pilot.

It has been possible to mention only briefly a portion of the work which is being done at the Bureau of Standards to insure that the airships our Navy builds are safe and that so far as possible all the resources of science, engineering and experience are being brought to bear upon the problem. The future of air navigation is full of promise, and in that future the airship has its place distinct from that of the airplane. It is surely fitting that the United States, which gave to the world its first successful airplane, should actively advance man's final mastery of the air.

ATMOSPHERIC DUST: IS IT HELPFUL OR HARMFUL?

By Dr. HERBERT H. KIMBALL

METEOROLOGIST, UNITED STATES WEATHER BUREAU, WASHINGTON, D. C.

This story is not going to be exciting, so my radio audience will be able to keep on breathing in a natural way; and those of you who are normal adults will inhale about twenty times a minute, and with each breath will draw about thirty cubic inches of air into your lungs, or six hundred cubic inches in a minute.

We are going to examine the solid particles, usually called dust, contained in the air we breathe. I will ask you to go with me to the campus of the American University, four miles northwest of the White House, on a ridge three hundred feet higher than the business section of Washington. During the World War the Chemical Warfare Service had its headquarters and experimental laboratories in this campus. The government still retains some of the laboratories, and in one of them we will examine samples of dust collected from the atmosphere.

It is a clear frosty morning, so my records say, of a particular April day, with little wind and a beautiful blue sky. To the north Sugar Loaf Mountain, thirty miles distant in Maryland, is distinctly visible, and we can also distinguish peaks of the Blue Ridge fifty miles to the west in Virginia. In the valley to the east and south, however, where the nearby cities of Washington and Alexandria should be clearly seen, we look out upon a murky cloud, the upper surface of which is only slightly undulating, and through which protrude the tops of the towers of the Arlington radio station. Presently, as the sun begins to warm the surface of the ground, the cloud rises and envelops the university, reducing the limit of visibility to three quarters of a mile.

On January 16 of this year, a cold, calm and clear day, at 10 a. m., hills to the north in Maryland ten miles distant were visible. To the east and south, however, Washington and Alexandria were again hidden from view. On Pennsylvania Avenue in Washington it was so dark that street cars and automobiles used headlights, while government and private offices resorted to artificial lighting.

What was there in the atmosphere of the city on that beautiful April morning that reduced the limit of visibility from fifty miles to three fourths of a mile? And what did it contain on the morning of January 16 that reduced the daylight intensity to that of twilight? The odor told us that at least a part was coal smoke, and I think you will be interested in the examination of the particles that make up the smoke.

We will collect the dust contained in a measured quantity of air, using for this purpose an instrument modeled after our breathing apparatus. For the lungs we will substitute a suction pump: for our mouth, a small metal box; for our lips, a metal plate containing a small slot, and we will attach to this plate a tube lined with wet blotting paper, so as to saturate the air with moisture as it passes through. In the box, directly in front of the slot, we will place a small and very thin glass disk—a microscope cover glass is just the thing.

Now make the apparatus inhale by a quick pull on the piston of the pump. This movement of the piston produces a partial vacuum in the metal box, and as the air enters moisture is condensed on the dust particles that came in with it. This so increases their weight and stickiness that they strike the cover-glass and adhere to it. If we quickly remove the cover-glass we will see upon it a fine whitish line of moisture. This moisture quickly evaporates, but the dust, though invisible to the naked eye, remains on the glass.

In the examination of this dust we use a microscope that magnifies the diameters of the particles one thousand times, and their cross-section one million times. With it we can count dust particles having a diameter as small as 0.000008 inch. Smaller particles neither reflect light nor cast a shadow and therefore can not be seen. It would be a tedious task to actually count every particle in the fine line of dust; hence we measure its length and breadth, count the number of particles contained in two or three typical bands across it and then compute the number in the whole line.

Air brought to the university from the open country by a northwest wind con-

tains about two thousand dust particles per cubic inch; that on an average morning at the university during the winter of 1925–26, about thirty thousand, and that from the smoky air of Washington about 115,000. During this winter, air in the northwest suburb has contained about fifteen times as many particles of solid matter as air from the country, and the air from the smoky city about sixty times as many. But 115,000 dust particles per cubic inch is not an unusual number for the atmosphere of large cities where bituminous coal is burned. In fact, five times this number is sometimes found.

Furthermore, the dust found in country air consists principally of finely powdered mineral matter, irregular in shape, which is taken up from the surface of the ground by the wind; a few crystals, principally salt, and in the warm months of the year pollen from plants and spores from rusts or molds. In the suburbs there are added to the country dust the products of combustion, such as soot and ash and compounds both of sulphur and tar. In the city there is an increase in the combustion products and also dust from building operations.

The average diameter of country dust particles is about two one hundred thousandths of an inch; that of suburban dust about twice, and that of city dust about three times as great. The entire two thousand particles from a cubic inch of country air if in a straight row and touching one another would form a line only .04 inch in length; those from suburban air would span 1.2 inches, while those from the city air would make a string 6.9 inches long. The suburban dust line is thirty times and the city line 170 times as long as that from the open country. The volume of dust from suburban air is 120 times, and that from city air is 1,550 times that from the country.

As to the actual mass of solid particles in smoky air; in the city of Pittsburgh in one year the fall of soot from the atmosphere was over one thousand tons per square mile, or enough for the whole city to make a close string of loaded ash carts 250 miles long. This was before the Mellon Institute of the University of Pittsburgh had developed methods of smoke prevention which have since been adopted with gratifying results.

Can any good come from the presence of dust in the atmosphere? Returning to our dust counter, when the air was cooled by expanding in the metal box between the dampening tube and the pump, the surplus moisture condensed on the dust particles. Had there been no dust particles there would have been little or no condensation. The same is true in nature. When air rises to pass over a mountain, for instance, it often cools to such an extent as to become saturated with moisture. Moisture will then begin to deposit on the dust particles in the air, forming a cloud, from which rain may fall. In the absence of dust particles there would be practically no condensation, no cloud and no rain. Fortunately, there always are sufficient dust particles in the air everywhere to form the necessary nuclei for condensation.

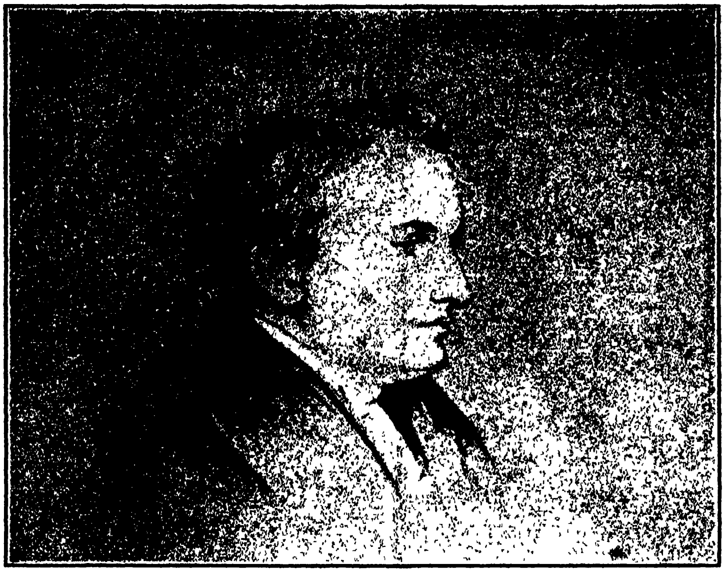
A smoke cloud, if dense, will retard the cooling of the atmosphere below it during the night. In fact, fruit growers formerly thought it necessary to form such a cloud over their orchards to protect them from damage when frost threatened. We now know that more effective protection is afforded by burning the fuel and thus producing heat to raise the temperature of the air in the orchard, rather than by forming an objectionable smoke cloud to prevent cooling. So we can not claim any virtue for smoke on the ground that it keeps the cities warm. Rather, it is an indication of an unnecessary waste of fuel.

But is smoke actually harmful? Certainly it is a nuisance because it is so filthy. It is an expense, because when it becomes dense, as on January 16 last, it diminishes the intensity of daylight to less than a quarter of that on a clear day,

and increases our bill for lighting. Furthermore, the city dweller wants to know what becomes of the sixty-nine million solid particles he often breathes in a single minute. If he breathes through his nostrils they will act very much like our cover glass in the dust counter and collect the dust particles, as his handkerchief is apt to show him. If he breathes through his mouth many of the particles will lodge in his lungs. Examination of the lungs of persons who had resided for a long time in smoky cities has shown them to be blackened by the soot from the air. Just what effect this may have upon health is for the medical profession to say. Some authorities claim that so much soot and dust increases our susceptibility to disease and especially to pneumonia. Furthermore, it cuts out from sunlight practically all the ultra-violet, which is known to be a powerful germicide. In consequence hospitals in large cities are equipped to treat diseases like rickets under artificial ultra-violet light, and sanitariums for the treatment of pulmonary diseases are built on mountains or plateaus where the ultra-violet component in sunlight is especially strong.

Does smoke produce fog? There are always a sufficient number of dust particles in the air to bring about condensation of moisture if the air is saturated. Some products of combustion are hygroscopic. That is, they absorb moisture, and may cause a light fog in air not completely saturated. Also, the presence of smoke particles in fog greatly increases its density and retards its dissipation. It is for these reasons that London has days of almost complete darkness due to the density and persistence of its black fogs.

A smoky atmosphere usually results from the general use of bituminous coal, especially for heating dwellings. It is noteworthy that the number of smoke particles in the air at the American University in the suburbs of Washington this winter is more than double the number for any previous winter. It is possible, however, to minimize, if not entirely remove, the smoke nuisance. Intelligent stoking of furnaces will do much. In addition, Dr. Cottrell, director of the Nitrogen Fixation Laboratory on the campus of the American University, has devised an electrical method of precipitating the solid particles in smoke before they leave the stack. There are other methods of preventing city smoke, all somewhat expensive. We are therefore called upon to decide whether we are willing to incur the trouble and expense necessary to insure clean air for city dwellers. Stated in another way, do we not prefer to spend time and money to keep the air of our cities clean rather than to suffer from the damage to health and property that results from the contamination of the air by smoke?



DAVID DOUGLAS
FROM A PENCIL DRAWING BY HIS NIECE, MISS ATKINSON

WHERE DOUGLAS PIONEERED

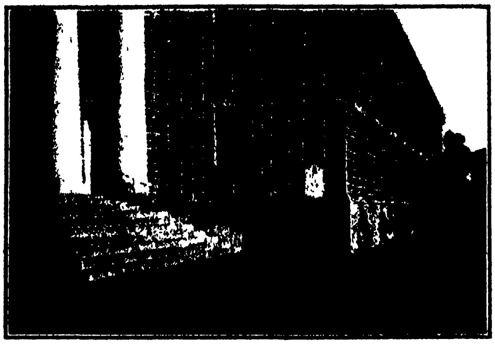
By Major JNO. D. GUTHRIE
U. S. FOREST SERVICE, PORTLAND, OREGON

ONE hundred years ago David Douglas, the young Scottish botanist, was exploring in the Pacific Northwest. By these explorations he added greatly to the sum of botanical and forestry knowledge of the Pacific coast. Had he nothing more as a monument, his name will ever live in the great Douglas fir forest of the west coast.

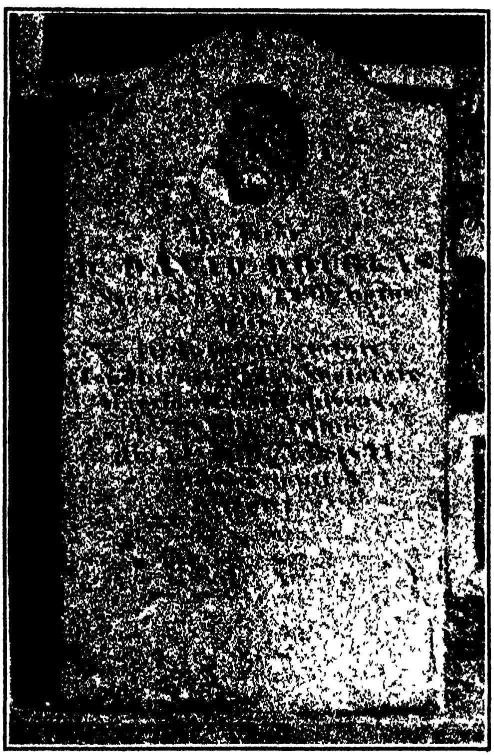
The list of American trees and plants which bears his name after their specific nomenclature is a long one. Sugar, western white, western yellow and digger pines, lovely and silver firs, are only a few; the list of plants and shrubs discovered and described by Douglas runs into the hundreds. His botanical explorations on the Pacific coast were truly those of a pioneer. His privations and self-sacrifice for science in the Oregon country of 1823 to 1830 were the more real ones because they had not for their goal material wealth, the common goal of men of that day and region. His too brief life reads like a romance.

He was but twenty-five years old when he first set out in 1823 from Liverpool for America. Born with a love for plants, he had served a seven-year apprenticeship as gardener to the Earl of Mansfield, followed by two years at Valleyfield, near Culross, where there was a notable collection of exotic plants. Then he received an appointment in the Glasgow Botanic Gardens where he came under the eye of Dr. William Hooker, the well-known botanist of that day. The Royal Horticultural Society became interested in the country of the Hudson's Bay Company and asked Dr. Hooker for recommendations as to a suitable person to be sent by the society on a botanical expedition to North America. It is significant of his botanic knowledge and qualifications as a scientist that young Douglas was recommended and appointed. He set out on June 3, 1823.

The results of his first mission, which was confined to the Atlantic seacoast,



THIS TABLET MARKS THE FINAL RESTING PLACE OF DAVID DOUGLAS.
IT IS ON THE CORNER OF THE "KAWAIAHAO" (CORAL STONE CHURCH) IN HONOLULU.



THE UNWEARIED TRAVELER TARRIES HERE AT LAST.
Photo by Board of Agriculture & Forestry, Honolulu.

was a large number of specimens of oaks. This collection he took back to England late in 1823.

He first came into the Columbia River on April 8, 1825, in the Hudson's Bay Company's ship *William and Anne,* after a trip of eight months and fourteen days from England. Dr. John Scouler was the ship's surgeon, also a naturalist of note.

Even before landing at Baker's Bay, near the mouth of the Columbia River, Douglas made a botanical entry in his journal: "The ground on the south side of the river is now, covered thickly with wood, chiefly *Pinus canadensis, P. balsamea,* and a species which may prove to be *P. taxifolia.*" Here was his first sight of the tree later to bear his name, Douglas fir, though he called it a pine, as well as the western hemlock and the lovely fir. On the 19th, he set out with the famous Dr. John McLoughlin, "the Father of Oregon," up the river on an expedition. His journal bristles with new plants and trees. Under that date he again mentioned Douglas fir, saying:

> I measured one lying on the shore of the river 39 feet in circumference and 159 feet long; the top was wanting, but at the extreme length 2½ feet in diameter, so I judge that it would be in all about 190 feet high if not more, girth 48 feet; they grow very straight; the wood is softer than most of the *Pinus* except *P. canadensis,* and easily split. The species, although I have not yet seen the cones, I take to be *P. taxifolia,* the most common tree in the forest.

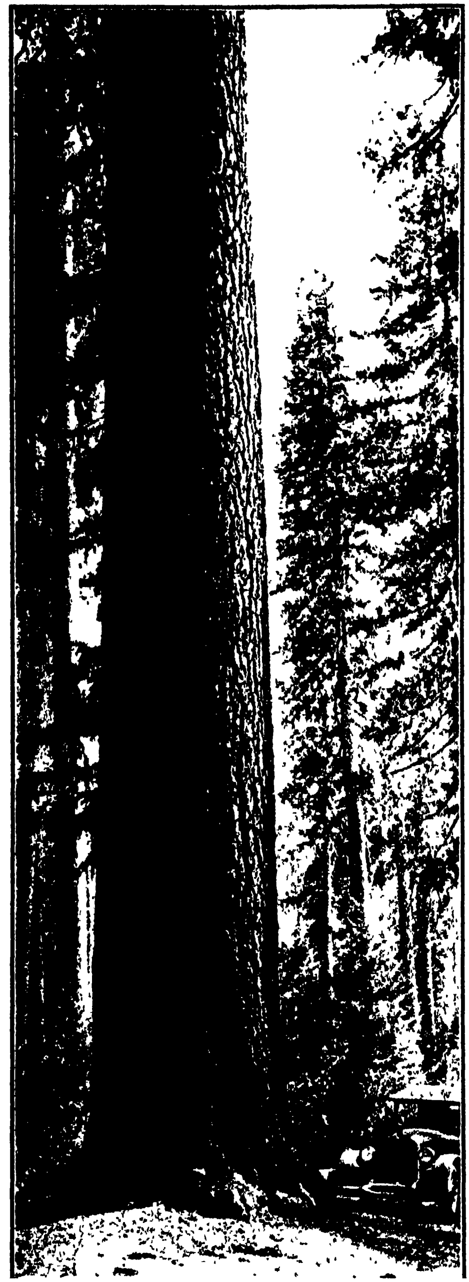
Douglas was a real pioneer. He spent three years in the Pacific Northwest, with the company's expeditions, with Indian guides, and alone, in this wilderness. He endured the severest kind of hardship, going hungry and sleeping cold and wet night after night in order that by depriving himself of cover he might carry paper for pressing his specimens and for keeping his notes. On many of his trips he had a bearskin and a single blanket for a bed, and finally, in the heavy rains, used his precious bearskin to wrap and protect his specimens. He had fever often when alone out in the trackless Oregon woods, and bled himself to relieve his temperature. He risked his life again and again, by flood and cliff, and with unfriendly Indians of that day.

Perhaps the most interesting of all the young Scot's finds are the Douglas fir and the sugar pine. Douglas fir, it is true, was first described by Captain Meriwether Lewis on the history-making trip with Clark, but the tree was not named until David Douglas' specimens arrived in England. First called *Pinus douglasii,* it was soon recognized that it did not have the characteristics of the pine. This tree passed through a varied nomenclature until it was finally named *Pseudotsuga taxifolia,* false hemlock. It has borne, and still does, a large number of common names, Oregon pine, red fir, yellow fir and others. Only in the English or common name is the real discoverer of the tree honored.

Douglas' finding of the sugar pine reads like a true pioneer's tale. He had first seen a few seed of this tree in an Indian's pouch near Oregon City. Scientist that he was, they instantly attracted his attention. The Indian told him that they came from a tall tree that grew far to the south. As is shown by many references in his journal, Douglas did not rest until he had seen this forest monarch. He had started south with one of the company's expeditions towards the Umpqua. The party turned west to follow the course of the river to the sea. Douglas, with an Indian youth as guide, went south and camped near the junction of Elk Creek and the Umpqua River.

On this first trip he was unsuccessful. He made a second exploring trip and found his pine, probably on what is now known as Sugar Pine Mountain, near Roseburg. Let him tell the story in his own words, as given in his Journal of Oct. 1826:

Thursday, 26th. Weather dull and cloudy. When my people in England are made acquainted with my travels, they may perhaps think I have told them nothing but my miseries. That may be very correct, but I know now that such objects are not obtained without a share of labour, anxiety of mind, and sometimes risk of personal safety. I left my camp this morning at daylight, on an excursion,



PINUS.

At midday I reached my long-wished Pinus (called by the Umpqua tribe Natale). This may have been the tree under which Douglas parleyed for his life with the Indians.

Photo by Board of Agriculture & Forestry, Honolulu.

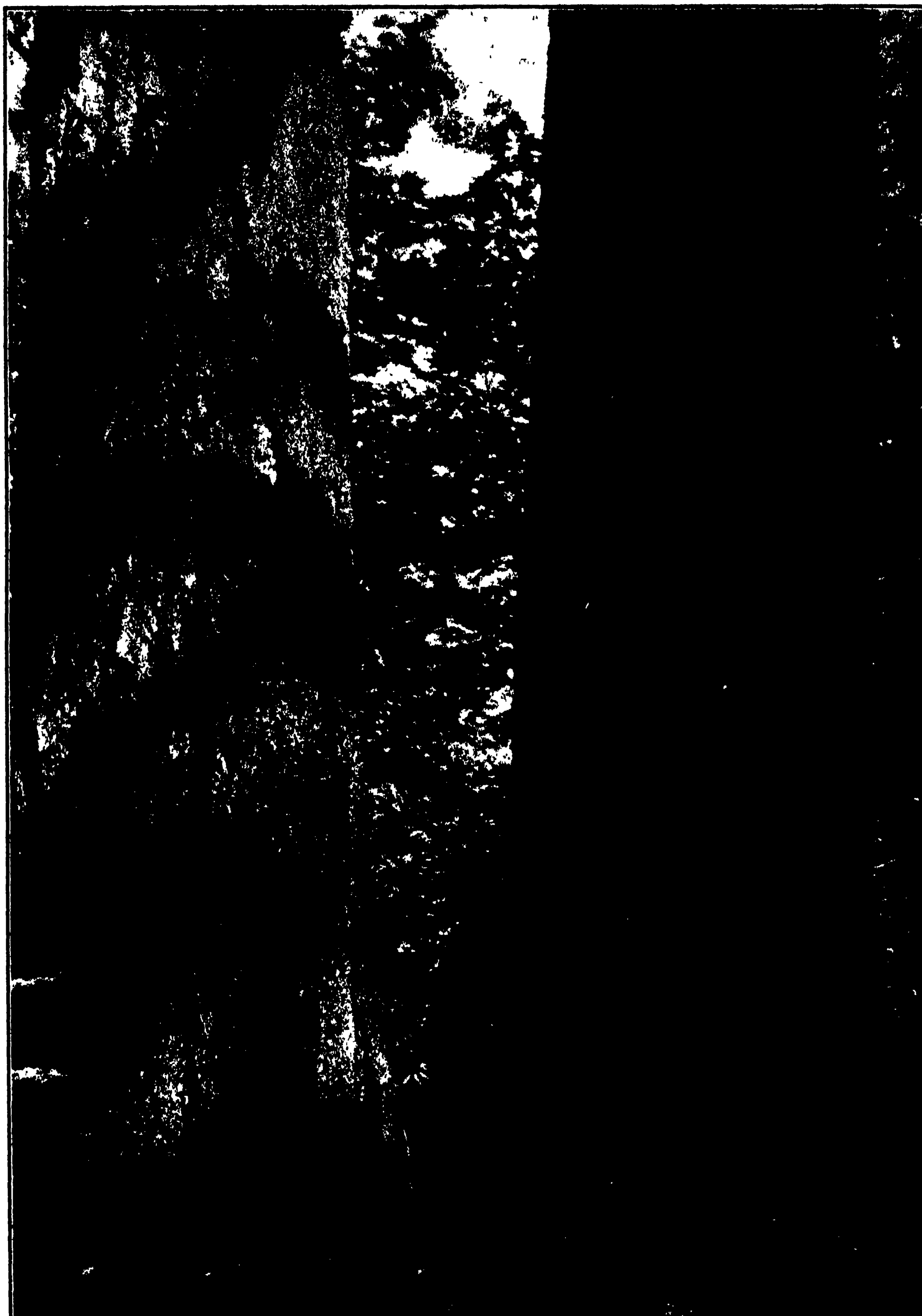


Photo by Weister

THE GREAT DOUGLAS FIR

HIS NAME WILL EVER LIVE IN THE GREAT DOUGLAS FIR FOREST OF THE WEST COAST.

leaving my guide to take care of the camp and horses until my return in the evening, when I found everything as I wished; in the interval he had dried my wet paper as I had desired him. About an hour's walk from camp I was met by an Indian, who on discovering me strung his bow and placed on his left arm a sleeve of raccoon skin and stood ready on the defence. As I was well convinced this was prompted through fear, he never before having seen such a being, I laid my gun at my feet on the ground and moved my hand for him to come to me, which he did with great caution. I made him place his bow and quiver beside my gun, and then struck a light and gave him to smoke and a few beads. With my pencil I made a rough sketch of the cone and pine I wanted and showed him it, when he instantly pointed to the hills about 15 or 20 miles to the south. As I wanted to go in that direction, he seemingly with much good will went with me.

At midday I reached my long-wished *Pinus* (called by the Umpqua tribe *Natàle*), and lost no time in examining and endeavoring to collect specimens and seeds. New or strange things seldom fail to make great impressions, and often at first we are liable to over-rate them; and lest I should never see my friends to tell them verbally of this most beautiful and immensely large tree, I now state the dimensions of the largest one I could find that was blown down by the wind: Three feet from the ground, 57 feet 9 inches in circumference; 134 feet from the ground, 17 feet 5 inches; extreme length, 215 feet. The trees are remarkably straight; bark uncommonly smooth for such large timber, of a whitish or light brown colour; and yields a great quantity of gum of a bright amber colour. The large trees are destitute of branches, generally two-thirds the length of the tree; branches pendulous, and the cones hanging from their points like small sugar-loaves in a grocer's shop, it being only on the very largest trees that cones are seen, and putting myself in possession of three cones (all I could) nearly brought my life to an end.

Being unable to climb or hew down any, I took my gun and was busy clipping them from the branches with ball when eight Indians came at the report of my gun. They were all painted with red earth, armed with bows, arrows, spears of bone, and flint knives, and seemed anything but friendly. I endeavored to explain to them what I wanted and they seemed satisfied and sat down to smoke, but had no sooner done so than I perceived one string his bow and another sharpen his flint knife with a pair of wooden pincers and hang it on the wrist of his right hand, which gave me ample testimony of their inclination. To save myself I could not do by flight, and without any hesitation I went backwards six paces and cocked my gun, and then pulled from my belt one of my pistols, which I held in my left hand. I was determined to fight for my life. As I as much as possible endeavored to preserve my coolness and perhaps did so, I stood eight or ten minutes looking at them and they at me without a word passing, till one at last, who seemed to be the leader, made a sign for tobacco, which I said they should get on condition of going and fetching me some cones. They went, and as soon as out of sight I picked up my three cones and a few twigs, and made a quick retreat to my camp, which I gained at dusk. The Indian who undertook to be my last guide I sent off, lest he should betray me. Wood of the pine fine, and very heavy; leaves short, in five, with a very short sheath bright green; cones 14½ inches long, one 14, and one 13½, and all containing fine seed.

Notice how the pioneer, having disposed of the Indians at the risk of his life, is again the scientist, describing in detail his new-found treasure!

The very next day his guide, about daylight while fishing, was attacked by a grizzly bear. Douglas went out later and found a large female, with two cubs. He shot one of the cubs and the mother, paying off his guide with the carcass of the young. He naïvely puts this down in his journal:

I abandoned the chase and thought it prudent from what happened yesterday to bend my steps back again without delay. So I returned and crossed the river two miles further down, and camped for the night in a low point of wood near a small stream. Heavy rain throughout the day.

This is but one episode of his life in the Oregon country of 1825. He went up the Columbia River as far as Kettle Falls, to Fort Spokane, and to Fort Colville, and back again, through hostile Indian country, boating at night for safety; he climbed Mount Adams twice within a few days; he traveled along the coast, and high up in the Cascades. He made three trips into the Blue Moun-

tains of eastern Oregon, he ascended Lewis and Clark Fork, back to Fort Spokane, thence overland to Okanogan, and back to Fort Vancouver. He sets down the estimated distances traveled as 2,105 miles in 1825, 3,932 in 1826 and 995 in 1827. He was interested in everything he saw, identifying and recording the fauna and flora, regardless of personal privation, lack of food, the rains or hostile Indians. At every opportunity he sent back to England the specimens and notes he was industriously collecting.

In January, 1827, after most carefully packing many precious specimens, which he had placed on the ship's invoice as "dry plants, seeds, preserved animals, and articles relating to natural history" for the Horticultural Society of London, he set out for Hudson's Bay! His companions were fifteen voyageurs, Hudson's Bay men, including four Canadians and three Iroquois Indians. Carrying on his back a tin box containing many seeds and his journals, he left Fort Vancouver on January 20, on "the annual express across the country," as he called it. What a journey that was, in the middle of winter! His account of this trip is filled with adventure, hardship and intense interest. Up the Columbia by Okanogan, Fort Colville, Kootenai River, on to the head of the Columbia River. After leaving the river because of its rapids, the party followed the trail afoot, on snowshoes, over snow-covered country to the northward-flowing streams, fording and refording the icy waters, all the time with his sacred tin box on his back.

Deep snows hid plants, but he was busy identifying the trees and collecting mineral specimens and worrying because he could not save numberless specimens of grouse, ptarmigan, fox, deer, caribou and bear. But he carried with him for over two thousand miles of this journey a fine specimen of the bald eagle, on whose accidental death he remarks: "What can give one more pain?"

He tarried at the posts on the Assiniboine River, still collecting, and at Norway House met Sir John Franklin returning overland from his second Arctic expedition. Douglas continued for Hudson's Bay on August 10, arriving there on August 28, most pleased to see the company's ship from England in the bay, on which he sailed for the homeland on September 15, 1827.

From the transactions of the Horticultural Society we learn that from the specimens and seeds which Douglas had sent home, 210 distinct species had been grown in the society's gardens, 130 of which were later "distributed to all parts of the world."

Douglas made several trips later, into the Columbia region, south to California and later tarried in the Hawaiian Islands, to his untimely death. He seems to have broken with the London society during this time, and his journals are not available, so that there is an unfortunate gap in his life.

The tragic nature of the untimely death of this brilliant young naturalist is a climax to his years of hardship and danger in the northwest country. Intensely interested in the new and tropical flora of the Sandwich Islands, he set out alone to go into the mountains from an Englishman's ranch in search of new plants, accompanied by a little dog. It will never be known how nor why, for he had been shown them, but somehow he fell into a pit dug by the natives for catching wild cattle, into which there had evidently fallen previously a wild bull. His mutilated remains were found the following day (August 13, 1834) and nearby his plant-case and the faithful little dog. English missionaries brought his body to Honolulu and buried it.

Thus at the early age of thirty-six did David Douglas give his life, but science was far richer for his having lived and pioneered in her behalf in the great Pacific Northwest.

BUST OF DR. WILLIAM H. WELCH

DIRECTOR OF THE SCHOOL OF HYGIENE AND PUBLIC HEALTH AT THE JOHNS HOPKINS UNIVERSITY, UNVEILED ON FEBRUARY 22, ON THE OCCASION OF THE COMMEMORATION DAY EXERCISES OF THE UNIVERSITY. DR. SIMON FLEXNER, DIRECTOR OF THE ROCKEFELLER INSTITUTE, MADE THE PRESENTATION SPEECH.

THE PROGRESS OF SCIENCE

DR. HORNADAY'S RETIREMENT AS DIRECTOR OF THE NEW YORK ZOOLOGICAL PARK

At the annual spring meeting of the board of managers of the New York Zoological Society, which was held in the Administration Building of the park on May 20, Dr. William T. Hornaday, who has recently completed thirty years of distinguished service as director of the New York Zoological Park, announced his retirement, to take place on June 1. When Dr. Hornaday announced his retirement, Professor Henry Fairfield Osborn, until 1924 president of the Zoological Society, offered the following resolution, which was unanimously adopted:

THE NEW YORK ZOOLOGICAL SOCIETY
Chartered April 26, 1895

The New York Zoological Society in its thirty-first year records its appreciation of
WILLIAM TEMPLE HORNADAY
planner and director of the New York Zoological Park since April 6, 1896; naturalist, nature lover, learned and voluminous author; zealous friend and protector of the wild life of North America.

Chosen in 1896 as the best qualified expert in the United States in zoologic park planning and administration, Dr. Hornaday studied all the great zoological parks of Europe, discovered the peculiar fitness of the South Bronx Park, transformed the meadow land and wild forest, and submitted the first General Plan in accord with the three great principles previously established by our Society:

The establishment of a free zoological park containing collections of North American and exotic animals, for the benefit and enjoyment of the general public, the zoologist, the sportsman and every lover of nature.

The systematic encouragement of interest in animal life, or zoology, amongst all classes of the people, and the promotion of zoological science in general.

Cooperation with other organizations in the preservation of the native animals of North America, and encouragement of the growing sentiment against their wanton destruction.

As administrative director of the New York Zoological Park for thirty years, Dr. Hornaday imparted, by his own example, continued intelligence, energy and enthusiasm, and inspired his increasing staff with loyalty and devotion to the spirit of public service, thus creating the largest and most beautiful, the most popular and the most widely known zoological park in the world.

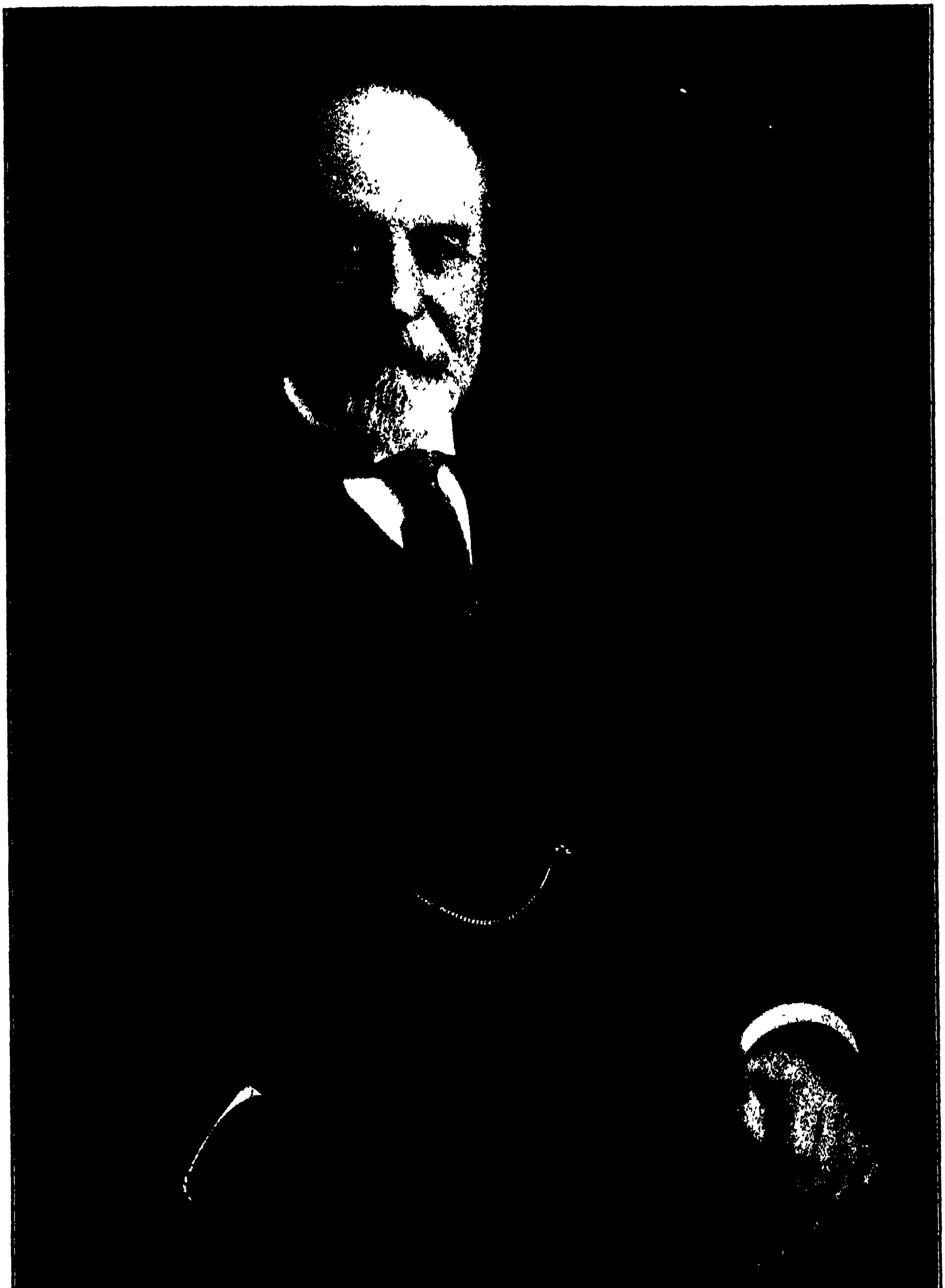
For these manifold services to public education and to zoology, the members of the
BOARD OF MANAGERS
make this permanent and grateful record of their appreciation, esteem and friendship.

The idea of a Zoological Park originated in the Boone and Crockett Club, in the autumn of 1894. On January 16, 1895, Theodore Roosevelt, president of the club, appointed a committee of three—Messrs. Elihu Root, C. Grant La Farge and Madison Grant, chairman—who persisted in the State Legislature until a charter was secured. The enabling act which brought the Zoological Society into corporate existence was successfully passed through the New York State Legislature by Mr. William White Niles, a member of the society, who, fortunately, at that time was a member of the assembly.

The New York Zoological Society started out with the purpose of extending and cultivating in every possible manner for the people of the City of New York a knowledge and love of nature. The initial objects of the society, expressed in the charter of 1895, were the following:

Said corporation shall have power to establish and maintain in New York City a zoological garden for the purpose of encouraging and advancing the study of zoology, original researches in the same and kindred subjects, and of furnishing instruction and recreation to the people.

The act to incorporate the New York Zoological Society, and to provide for the



W. T. HORNADAY

DR. WILLIAM T. HORNADAY AND DR. W. REID BLAIR

IN THE NEW YORK ZOOLOGICAL PARK WITH THE FIRST MUSK-OX CALF TO BE BORN IN CAPTIVITY.

establishment of a zoological garden in the City of New York was accepted by the city, and became a law on April 26, 1895.

Dr. Hornaday was appointed director of the newly formed Zoological Society on April 1, 1896, and after making a complete study of the various available parks in New York City brought to the attention of the Executive Committee the fact that the southern half of Bronx Park offered an ideal site for the proposed Zoological Park.

Here he found a wonderful combination of hill, of high ridge and deep valley, of stream and pond, rolling meadow, rocky ledge and virgin forest, of the finest description, all of which, by a happy combination of circumstances, had been preserved intact for many years. After the city authorities set aside Bronx Park as a site for the Zoological Park, Dr. Hornaday drew up a general plan in which he endeavored to preserve all the natural features of the park, so far as possible without cutting any of the fine trees. This plan provided for an inner circle of large, permanent buildings, and an outer circle of large, semi-wild natural enclosures, consisting of ranges of from two to twenty acres in extent. It is interesting to compare the plan for the Zoological Park as adopted unanimously by the Executive Committee on November 9, 1897, with the Zoological Park today, and to note how very few changes have been made, and these only in minor details.

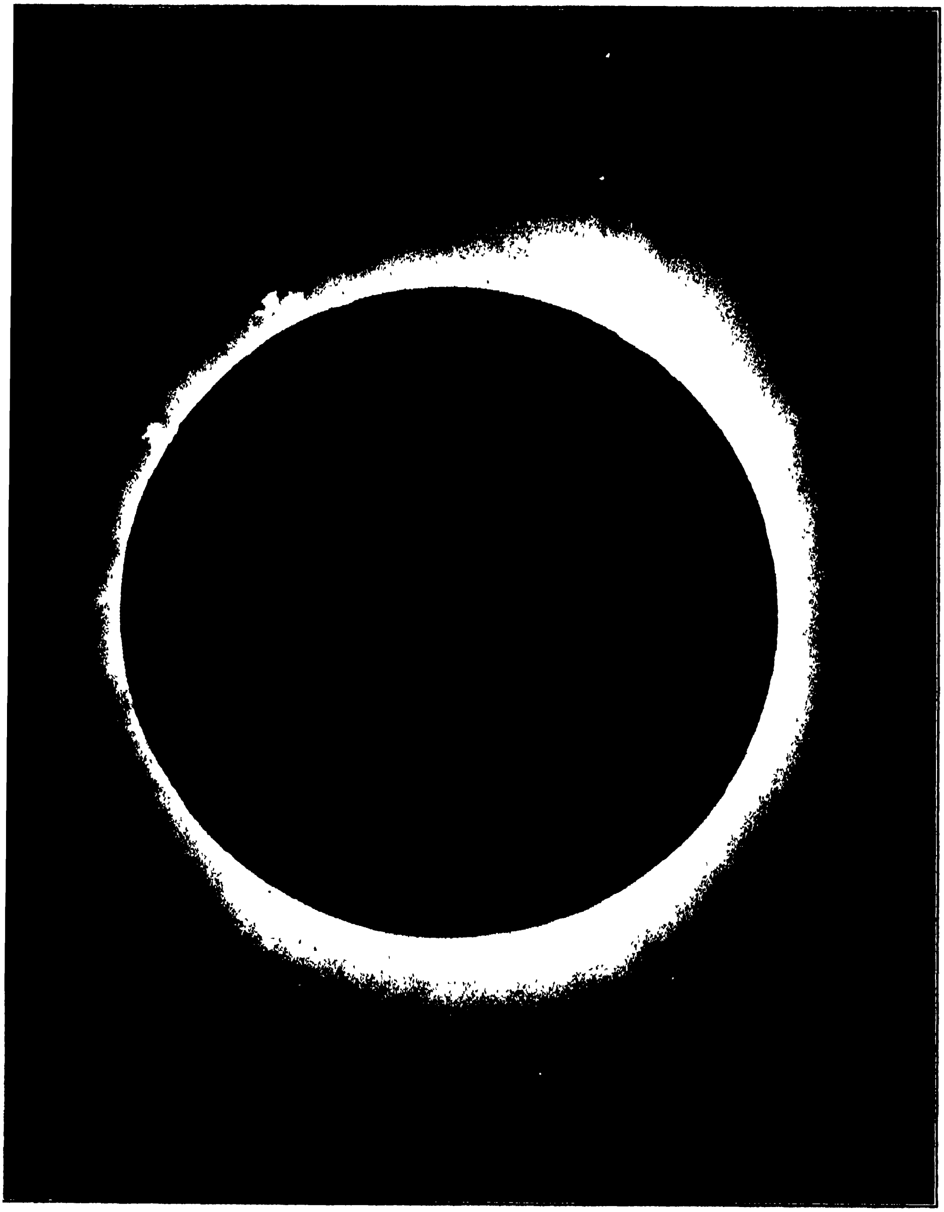
The active work of building the Zoological Park began on August 15, 1897, and continued during the next eighteen years. The Zoological Park was opened to the public on November 8, 1899. From that date to this the total attendance has been about 44,000,000. When the grand rush of construction in 1899 ended with the formal opening of the unfinished Zoological Park on November 8, 1899, the entire collection of twenty-two installations for mammals, birds and reptiles had been created by the Zoological Society at the expense of its own treasury. Automatically they became the property of the city as fast as they were completed.

On June 10 the Zoological Society presented to Dr. Hornaday a gold medal as a tribute to his thirty years of service. In presenting this medal Mr. Grant, the president of the society, spoke of Dr. Hornaday's intimate knowledge of wild animals in their native haunts, acquired during his world-wide travels before he took charge of the Zoological Park.

"There have been plenty of men who were hunters, Indian hunters and frontiersmen in our own country, who knew the animals in their wild state," Mr. Grant said, "but they were not men of training and observational ability, to mark down, interpret and record what they saw. Dr. Hornaday was one of the last to be able to see wild life in its former state, and one of the first who had the education, the training, the industry and interest to put those facts on record."

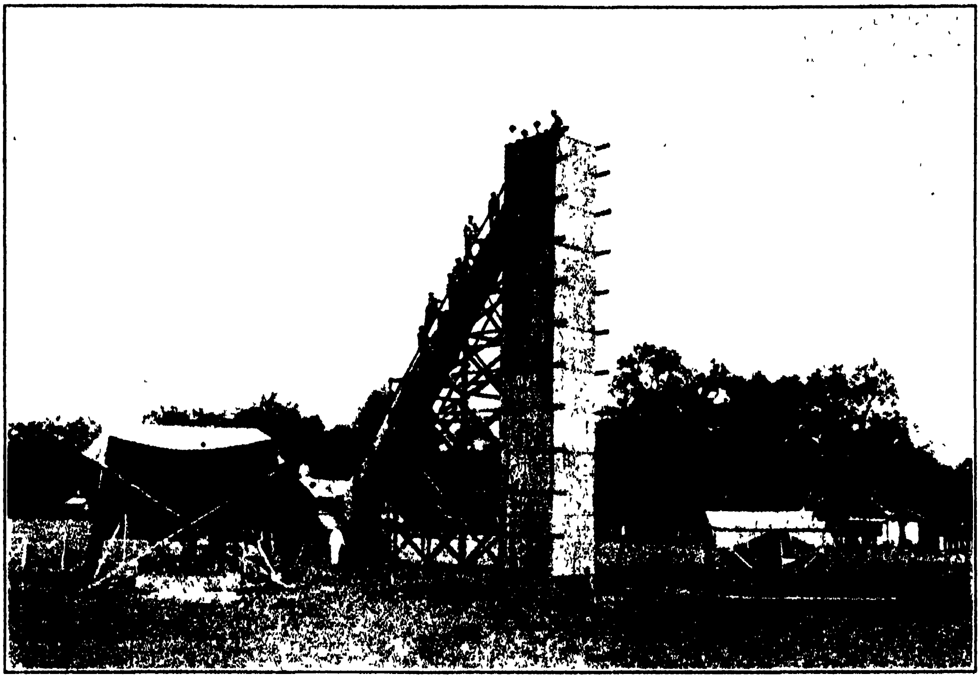
Dr. W. Reid Blair, who succeeds Dr. Hornaday as director, is of Scotch ancestry, and was born in Philadelphia, January 27, 1875. He was graduated from the department of comparative medicine and veterinary science of McGill University in 1902. While in college he specialized in comparative anatomy, pathology and psychology, acting as secretary of the Society for the Study of Comparative Psychology founded by the noted psychologist and physiologist, Professor T. Wesley Mills, of McGill University.

Immediately upon graduating, Dr. Blair accepted a position on the scientific staff of the New York Zoological Park for the purpose of studying the diseases of wild animals in confinement. He has made numerous contributions to scientific publications dealing with the comparative pathology of wild animals.



THE SOLAR CORONA.

Photograph taken with the 65-foot focal length camera by E. C. Brauer, Chief Photographer of the United States Navy. Half size of the original plate.



GENERAL VIEW OF THE STATION AT KEPAHIANG, SUMATRA.

From 1905 until 1917, Dr. Blair was professor of comparative pathology in the veterinary department of New York University. During the World War he was commissioned major in the Veterinary Corps of the U. S. Army, serving in France and Germany as chief veterinarian of the Fourth Army Corps. He now holds a colonel's commission in the Officers' Reserve Corps. He has been assistant director of the New York Zoological Park since 1922.

THE U. S. NAVAL OBSERVATORY ECLIPSE EXPEDITION TO SUMATRA

IN the quest of eclipse observations astronomers have journeyed to the far ends of the earth, but it must be very rarely that the same astronomers have traveled a second time over the same route to almost the same place half way round the globe to witness and observe this most wonderful and awe-inspiring phenomenon. This happened in the case of two of the astronomers of the U. S. Naval Observatory expedition to observe the recent total solar eclipse of January 14, 1926, in the Island of Sumatra. In 1901 they occupied stations near the middle of the island, and in 1926 in the southwestern part, in the little village of Kepahiang, 35 miles from the well-known seaport town of Benkoulen, at which place several other parties were located. Captain F. B. Littell, Corps of Professors of Mathematics, U. S. Navy, who had observed the eclipse of 1901, in Solok, was in charge of the expedition, and Associate Astronomer G. H. Peters, who had observed the 1901 eclipse in Fort de Kock, accompanied him. With them were Dr. J. A. Anderson, of the Mt. Wilson Observatory, also a veteran eclipse observer, who was in charge of all the spectrographic work, and Assistant Astronomer G. M. Raynsford, of the Naval Observatory. Lieutenant H. C.

GROUP OF ASTRONOMERS, SAILORS AND MALAY ASSISTANTS ASSEMBLED AT THE BASE OF THE STATION. THOSE STANDING (FROM LEFT TO RIGHT) ARE F. B. LITTELL (IN CHARGE), CAPT. U. S. NAVY (MATH.); DR. H. C. KELLERS, LIEUT. MEDICAL CORPS, U. S. NAVY (IN CHARGE OF SMALL POLAR AXIS); G. H. PETERS, ASSOCIATE ASTRONOMER, NAVAL OBSERVATORY (IN CHARGE 65-FT. INST.); DR. J. A. ANDERSON, PH.D., PHYSICIST, LAB. MT. WILSON SOLAR OBSERVATORY, PASADENA, CALIF.; G. M. RAYNSFORD, ASST. ASTRONOMER. NAVAL OBSERVATORY (IN CHARGE LARGE POLAR AXIS).

Kellers, Medical Corps, U. S. Navy, was a member of the expedition, and in addition represented the Smithsonian Institution in collecting entomological and zoological specimens. A party of seven enlisted men of the navy was detailed to assist in the work of erection of instruments, and in the observations of eclipse day.

While the Island of Sumatra may be described as being in a somewhat backward state of civilization, much progress was noted as compared with the condition twenty-five years ago. The economic condition seemed to be very prosperous, due to the high prices of rubber and coffee, and the exploitation of extensive petroleum deposits. It was feared that transportation beyond the hundred miles of railroad might still have to be made by the primitive ox- or carabao-cart of the olden times, which while sure was tantalizingly slow. However, it was found that automobile transportation service was maintained over good roads across the island, and rapid progress was assured. There is government ownership of railroad and auto truck transportation service, and by the courtesy and generosity of the Dutch government all eclipse expeditions with their apparatus were transported without charge from the port of debarkation to their destinations. The courtesy and helpfulness of the Dutch officials and residents of the island can not be too highly commended.

It was well known that all eclipse expeditions going to observe this eclipse were taking a long sporting chance on the weather, for it occurred in the middle of the rainy season. From the data available it appeared that the chance of favorable weather was about one in three. Taking account of its previous experience in 1901, the Naval Observatory located in a somewhat elevated region just east of the first range of mountains that follow the west coast. The weather conditions there proved to be about as expected, or a little less favorable, as to cloudiness. The temperature was quite comfortable on the whole, the extreme range being from 64° at night to 90° in the afternoon. During the rainy season there were intervals of comparatively good weather, and the day of the eclipse was in the midst of such an interval. Yet just at the time of totality a cloud obscured the sun for two of the three precious minutes of its duration.

A number of excellent photographs of the eclipsed sun were obtained during the minute when it was shining through rifts in the cloud. The photographs taken with the 65-foot camera, which was pointed directly at the sun, show an abundance of interesting detail in the structure of the inner corona, and will repay careful study and discussion. On account of the partial obscuration by the cloud, no great extension of the corona was evident on the plates, and for the same reason the spectrographic plates were impressed by only a few of the strongest lines.

The moving picture apparatus, being readily transportable, was sent in an automobile to seek a region of clearer sky, and with it a good film was secured, showing the general features of the corona and considerable extension.

The first, third and fourth contacts were observed, giving the following corrections to the predicted times, I + 29.0 seconds, mean of two observers, III + 1.4 seconds, one observer, IV - 4.0 seconds, mean of two observers.

It is interesting to note that Sumatra is to be favored with another eclipse on May 9, 1929, with a duration of 5 minutes, which is considerably longer than that of this year.

Especial mention should be made of the elaborate arrangements made for the accommodation and comfort of all the

eclipse parties, due to the foresight and efforts of Director Vouté, of the Bossche Observatory, Lembang, Java, and of Mr. Kerkhoven, of Bandoeng, Java, Secretary of the Netherland-Indian Astronomical Society, and of the ever-helpful activities of Controleur Wink, of Kepahiang.

A "PSALM" OF LIGHT

By Beta

Tell me not in Einstein's numbers
Time is but an empty dream
And the space is dead that cumbers
And things are not where they seem.
Time is real, space is earnest
V o'er c is but a tool
With which thou perhaps discernest
But a jot of nature's rule.
Not Minkowski, no nor Riemen,
Framed our destined end or way;
Nor yet Maxwell nor his demon
Fix the ether or its sway.
Larmor's curls and Planck's equation
Order not one single flash,
Nor can Lorentz' transformation
Transcend mortal's mental hash.
Whims of wranglers all remind us
"As the twig, the tree's inclined."
And howe'er their bents may blind us
"Naught exists without the mind."
Wrangler's art is set on axioms,
Man-conceived, by man expressed
And like most of man's contraptions
May have faults when brought to test.
Let us then not be excited
Just because the starlight curves:—
Euclid's line was thought, not sighted,
Common sense, as ever, serves.

THE SCIENTIFIC MONTHLY

AUGUST, 1926

BOYCE THOMPSON INSTITUTE FOR PLANT RESEARCH

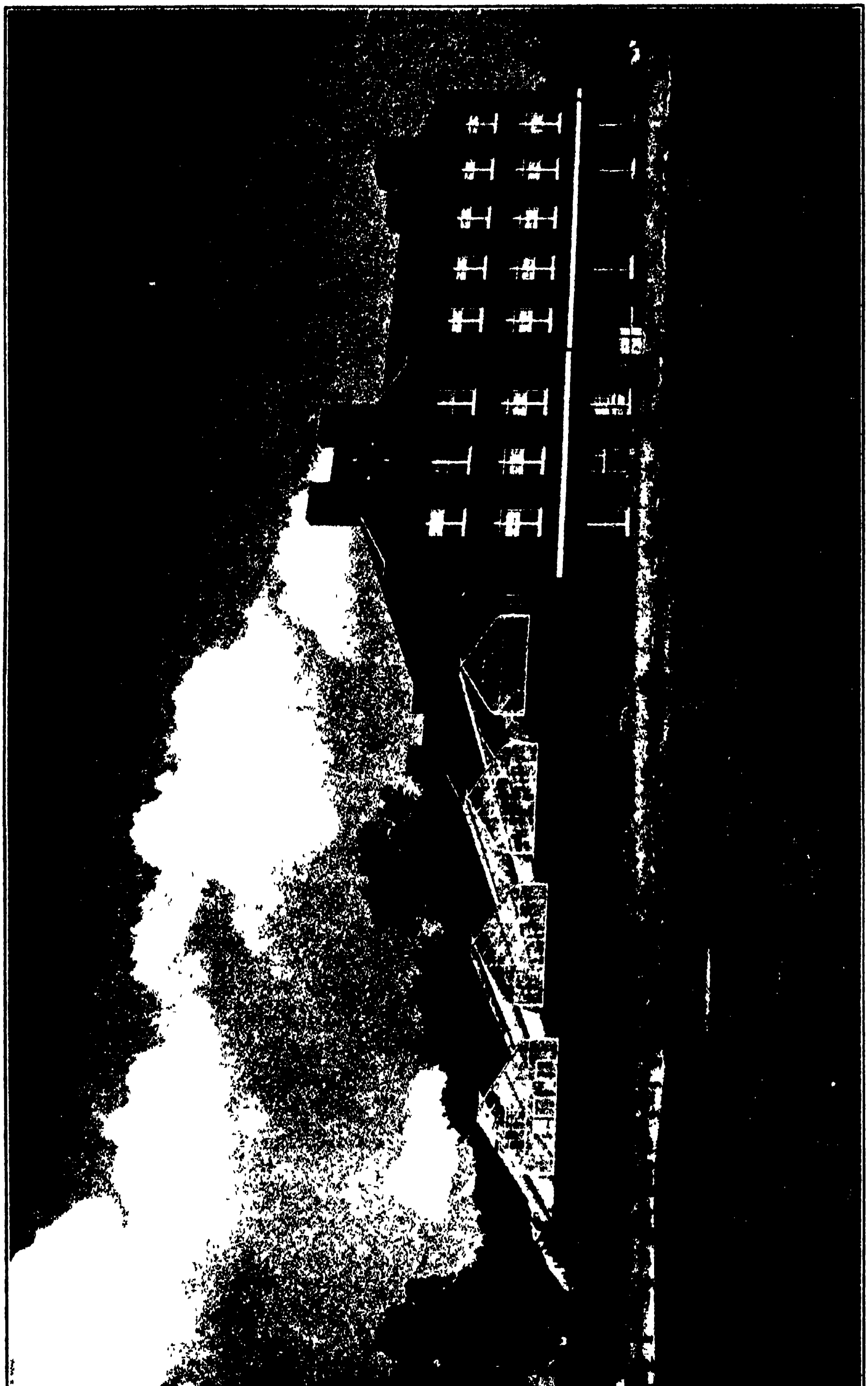
By Professor JOHN M. COULTER

BOYCE THOMPSON INSTITUTE

THOSE who are interested in the progress of science and of its service to human welfare should be informed of the work of the Boyce Thompson Institute for Plant Research, at Yonkers, New York. Colonel William Boyce Thompson had become impressed with the dependence of the whole population upon plants and their products. He felt that a great public service could be rendered if a more effective handling of plants could be secured. He realized that the problem was not merely to improve practice already in use, but through fundamental research to discover the possibilities of new practice. With this in view, the institute was planned and was officially opened for work in September, 1924, with sufficient endowment to provide the necessary equipment. It should be understood, however, that it is not a completed equipment, but an initial one. Further equipment will be secured as problems arise, so that the institute is a growing organization and not a static one.

The general aims of the institute at present may be summarized under three heads: (1) to secure the best possible equipment for the study of the entire life of plants; (2) to organize a cooperative staff representing every technique for attacking problems; (3) to attack the fundamentals of practical problems. In general, the botanical laboratories in America were poorly equipped for plant research. For example, they lacked good equipment for laboratories dealing with physics, chemistry, microchemistry, etc., as applied to plants. There was need also of special equipment for the study of plants during their entire life under controlled conditions. The equipment ordinarily available secured responses for only a short period, which did not apply to the whole life of the plant, and this resulted in many mistaken conclusions. The present equipment at the institute enables plants to be grown under controlled conditions, such as light of varying intensity, duration and quality, also varying temperature and moisture. In this way the whole series of responses of the plant throughout its life is secured, resulting in what may be called developmental physiology.

The staff includes investigators trained in all kinds of technique necessary for solving botanical problems. At present, physiology, pathology, biochemistry, physical chemistry, microchemistry and morphology are represented. In each of these fields of work there are varying phases of technique. For example, pathology includes bacteriologists, entomologists, protozoologists, etc. The same is true of the other depart-



BOYCE THOMPSON NSTITUTE FOR PLANT RESEARCH—EAST ELEVATION.

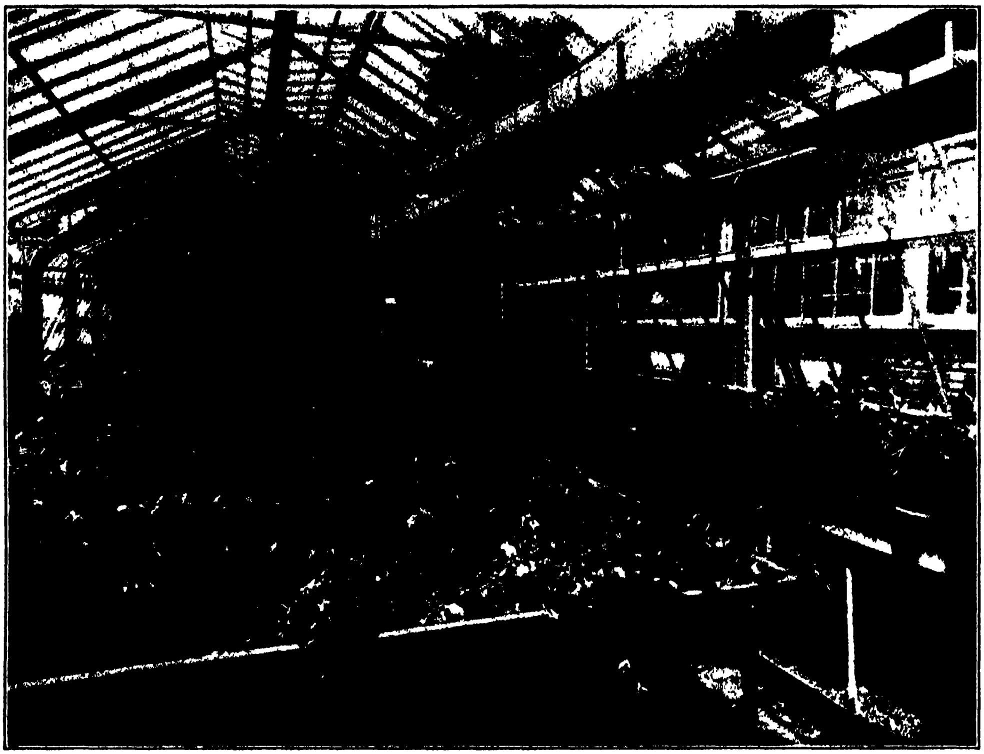
ments. All these phases are related to each other in the life of plants, and therefore the different investigators do not work separately, but in cooperation. It is recognized that plant life is a synthesis of all the sciences working together in producing the results. Probably the most important feature of the institute is the recognition that all phases of science must focus on a problem. One illustration of this cooperative attack may be taken from the investigation of the mosaic and yellow diseases of plants, in which the following lines of technique are being applied: pathology, entomology, protozoology, microchemistry, anatomy, biochemistry, physical chemistry and ultra-photography.

There are at present about thirty regular investigators at work, in addition to which there are thirty-three helpers to care for the many necessary details in connection with the investigations and the equipment. In addition to the permanent staff, a number of institutions, educational and commercial, are cooperating in supporting investigators to take advantage of the unusual equipment. In this way the institute is cooperating with other institutions in their investigation of fundamental problems.

A brief statement of the present equipment may be of interest, since it is probably the most complete and effective equipment at present for botanical investigation. The present building, which is only a section of the building planned, contains numerous laboratories, each with a very complete equipment for its purpose, but all of them coordinated in such a way that they can work together. In addition to the laboratories, there are sixteen greenhouses, providing for a wide range of control conditions. The controls already provided for include temperature, constant light and darkness, extra light, spectral illumination, humidity and carbon dioxide supply. A notable piece of equipment is that for supplementing daylight by artificial light at night. It is secured by means of an enormous gantry crane, which can be moved over the greenhouse at night and removed during the day. Its illuminating intensity is equivalent to that of daylight, so that the effect of daylight can be prolonged through any desired period. A few selections from the many problems being investigated at the institute will be made by way of illustration.

Propagation Studies

The institute is making extensive investigations of propagation from seeds and from cuttings, much of it in cooperation with nurserymen. It is found that seeds that need imbedding in soil preparatory to germination, called "stratification," depend chiefly upon the temperature of the soil bed. For example, the best temperature for many seeds is found to be about 5° C., but practice often fails through lack of proper control. The length of time necessary for stratification, to secure "after-ripening," is found to vary widely with different plants, even of the same genus. For example, in the rose genus, it is found that one species requires sixty to eighty days of stratification, while another species needs 120 to 140 days. In seeds that require short periods of stratification, sowing in the fall out-of-doors gives the desired result. In cases where a much longer period is needed for after-ripening, it seems probable that it can be secured by controlled cold storage, followed by a winter in properly treated beds, the seeds thus becoming ready for germination in early spring. The two things to be determined are the best temperature for after-ripening and the necessary length of time. Information in reference to these two factors is being supplied. For example, such information was asked by a nursery concerning



GREENHOUSE EQUIPPED FOR HUMIDITY CONTROL.

a certain dogwood, and the answer secured was that the best temperature is 33° F., and the time needed is four and a half to five months.

The investigation of propagation by means of cuttings is yielding important results. The factors studied are time of making the cutting, length of cutting, position of cutting and the effect of soil and chemical stimulants. It is found that plants propagated in this way vary widely in respect to these factors. What is good practice for some forms is ineffective for others. These propagation studies have proved of great interest to nurserymen and have suggested improvements in practice that are being adopted. The institute is being called upon to solve more commercial research problems than it can care for. As a consequence, its policy is to select from the numerous problems presented only those that promise progress in science and improvement in practice.

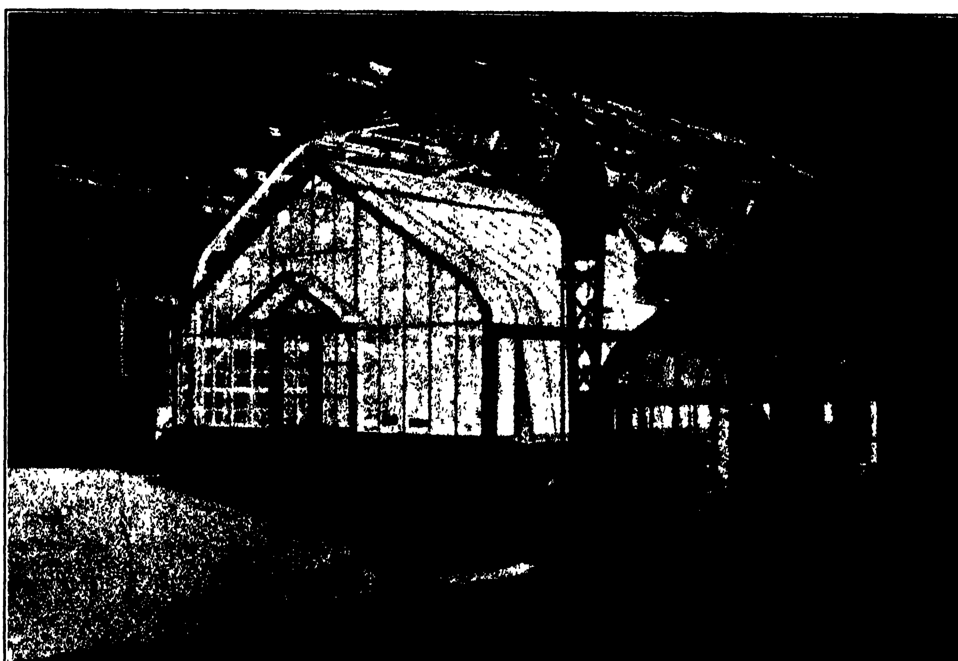
Chemical Regulation

The investigation of this problem has to do with the effect of chemicals upon awakening the plant from dormancy and securing immediate growth. The potato tuber was selected as the subject of experiment, not only because it is a notably dormant structure, but also because if it can be forced into speedy activity the result will prove of great practical importance. The problem was to discover the margin between the forcing action and killing action of the chemical. The extent of the experimental work may be realized from the fact that 224 different chemicals were tested, involving the use of about 3,000 separate experimental lots. The tubers were treated both cut and whole, and exposed to the chemical

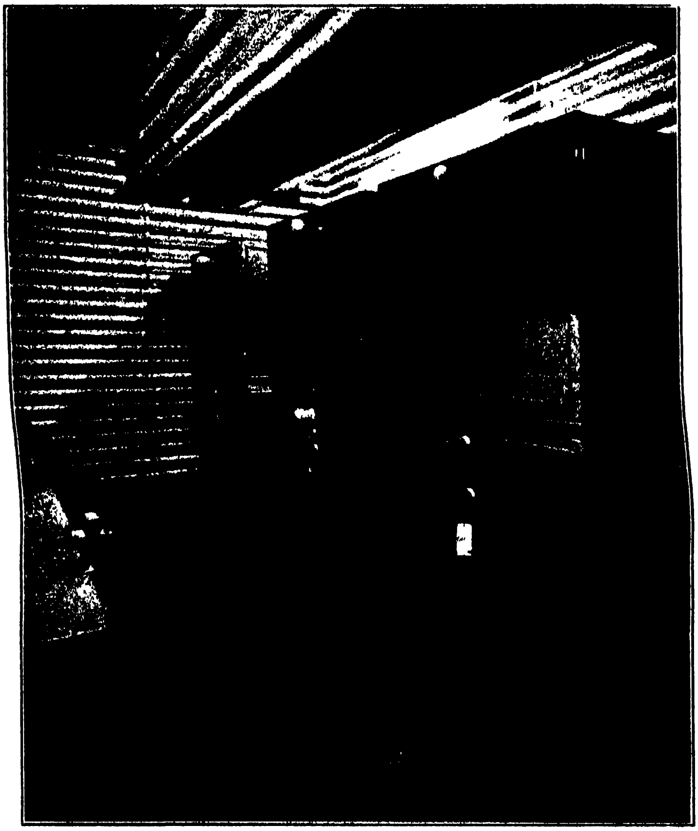
usually for one hour. By far the most promising chemical proved to be an ethylene compound (ethylene chlorhydrin), whose vapors were found to be remarkably effective in causing prompt germination. For example, in the experiments with a certain crop of potatoes, the treated lot produced vines two feet high, bearing tubers, before the untreated checks had appeared above the ground. The reason for this effect of the ethylene compound is evidently due to the fact that there is a very wide margin between forcing action and killing action. This forcing action in plant growth has opened up a very wide field in the handling of plants and proves to be not only of scientific value, but also promises to be of great practical importance. Work is proceeding to determine a standardized procedure in the use of ethylene chlorhydrin. It is certainly effective, but it remains to be discovered whether it can be put to practical use.

Certain other chemicals gave favorable results, but none seemed so effective as ethylene chlorhydrin. An interesting special case is presented by the chemical known as thiourea. In proper concentration it not only caused prompt sprouting of the potato, but also caused the development of more than one sprout from a single "eye," sometimes as many as eight. This means that in some way this chemical overcame the inhibiting effect of the main bud of the eye upon the subsidiary buds.

In this connection, attention may be called to the fact that the physiological chemistry of plants is far behind that of animals. This is probably due in part to the fact that such investigation is far more difficult in plants than in animals and also to the fact that the science of medicine has long been engaged in intensive work with animals. In animals the effect of what are called chemical regulatory agents is relatively easily studied,



GREENHOUSE ILLUMINATED AT NIGHT BY GANTRY CRANE.



REFRIGERATION ROOM WITH TEMPERATURE CONTROL CHAMBERS.

for animals have special glands for producing these substances, and an easy method of distributing them by the circulatory system. In plants there is no such specialized mechanism, and each cell must produce the regulative agents. This results in a very difficult problem for investigation.

Developmental Physiology

The investigations under this head are concerned with the effect of controlled conditions upon plant growth. The conditions under control are light, temperature, humidity and carbon dioxide. These controls are applied, associated with checks, throughout the whole history of the plant, from the seedling stage to maturity. Many plants have been subjected to these experiments, representing every combination of control, to discover the growth conditions. As might be expected, plants vary widely in their responses, and no result applies to plants in general. For example, it was found that the tomato and certain other plants suffer from daylight that lasts longer than seventeen hours. On the other hand, spring barley, petunia and some other plants were found to flower quickest and yield heaviest in continuous illumination, food manufacture proceeding uninterruptedly at the maximum rate. Investigation with other kinds of controls is also yielding important information.

Nutritional Physiology

This involves the chemical analysis of plants to discover what they are using

in the various tissues. Many of the methods in use are known to be inaccurate, sometimes accurate enough for certain plants, but not for others. The methods in use were investigated, to determine the limits of their usefulness and also to improve them if possible. As a result, some of them were found to be more reliable than others, and with the improvements suggested they can secure reliable results. For example, a method in use for the determination of reducing sugars was found to be accurate in its results under certain conditions. A method used for the estimate of total nitrogen in plant tissues was found to give too low results, but certain modifications promise to secure accuracy.

A special investigation was made of the tissues of apple trees and a method of analysis was worked out by which it is possible to secure accurate determinations of certain important compounds. At present there is no accurate method for the determination of starch in plant tissues, and therefore a promising investigation is in progress to secure an effective method.

A very interesting and important investigation in progress is the study of the seasonal changes in the apple tree. One hundred and fifty eleven-year old trees were secured for this study, and the seasonal changes in the chemical composition of the various tissues determined from the time of leaf fall in November to the period of fruit bud formation during the next season. The bark and wood of various years were analyzed at suitable intervals, to determine the chemical changes that were occurring. This is but a part of the general problem of the chemistry of fruit bud formation in the apple.

In addition to these major enterprises in nutritional physiology, there has also been cooperation with the investigations in certain diseases, as yellows and mosaic.

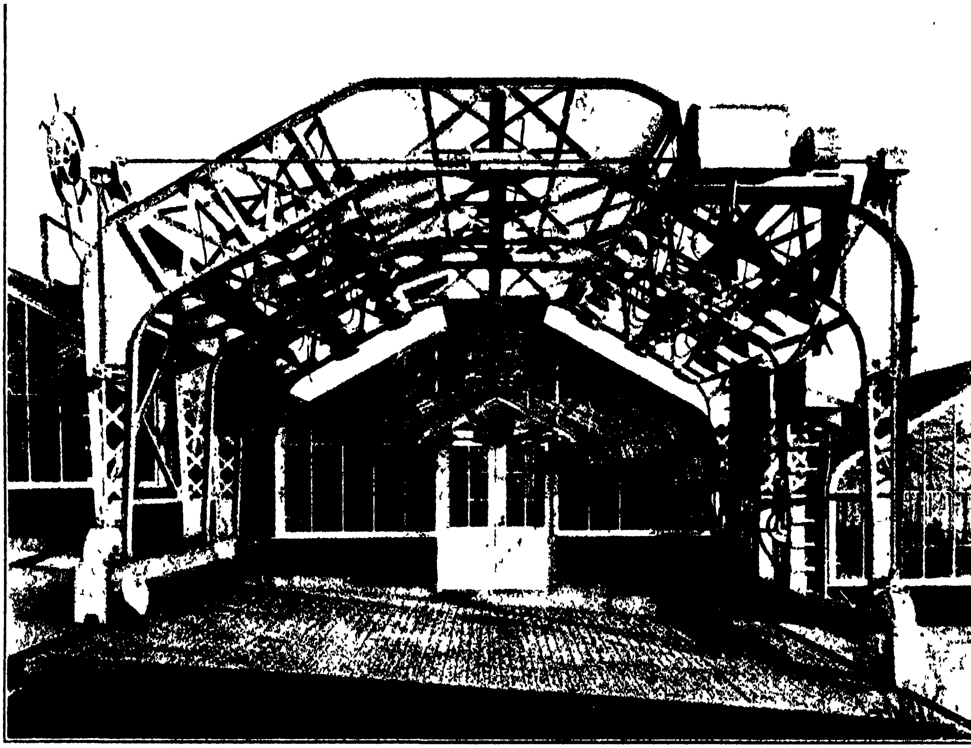
Another phase of work in nutritional physiology is concerned with the growth-producing value of the foods stored in various seeds and the effect of varying proportions of these organic foods in altering the shoot to root ratio. Seeds varying in the proportion of carbohydrates to nitrogen have been allowed to develop seedlings on their own nitrogen reserves in light, in darkness and in light in atmospheres containing carbon dioxide and lacking carbon dioxide, except for the small amounts given off in respiration. In all these conditions, the effect of additional nitrates was also studied. A great many interesting results have been obtained, showing wide variation in the behavior of different seedlings. For example, in the case of seedlings grown in darkness on their own nitrogen reserves, the total growth in grams of green material produced per gram of original dry food material ranged from 4.86 grams for low-protein corn to 32.51 grams for sunflower seed, a high-protein, high-oil seed.

A brief summarized statement will indicate some of the notable results thus far.

Seedlings from low-protein seeds, as corn, respond more to nitrates than to carbon dioxide or light. Seedlings from high-protein seeds respond to carbon dioxide and light more than they do to nitrates. Increased carbon dioxide and light have more effect upon the growth of roots than of shoots; while nitrates have more effect on the growth of shoots than of roots.

Plant Diseases

The investigation of plant diseases is another important field of work. This involves the discovery of the cause of a disease and then the development of some effective method of prevention. Many diseases are being investigated at the institute, but the most striking results have been obtained from the work upon mosaic and yellow diseases, and the latter will be used as an illustration. The yellow diseases have long been a



GANTRY CRANE FOR ILLUMINATING GREENHOUSES.

puzzle, and for many years their investigation has occupied the attention of plant pathologists. For example, peach yellows has destroyed many orchards, and yet it could never be discovered how the disease was carried from diseased to healthy trees. In attacking this difficult problem, the pathological division of the institute first studied aster yellows, a similar disease of asters, and succeeded in discovering the particular insect that carries the disease. This is only the first step in solving the problem, for it remains to be discovered what the insect carries that causes the infection. The carrier for aster yellows infects many other plants also, so that the infection may be carried over to quite a range of plants. The carrier for peach yellows, however, still remains to be discovered, but the pathologist is "on the trail." After the carrier and the thing carried are discovered, the final problem is to work out methods of effective control. Much work has also been done in connection with the diseases of decorative plants. This field has received comparatively little attention previously, because the chief attention of plant pathologists has been given to food-producing plants. The study of the diseases of decorative plants is being carried on in cooperation with nurserymen, florists and horticulturists, so that there is no lack of material and problems.

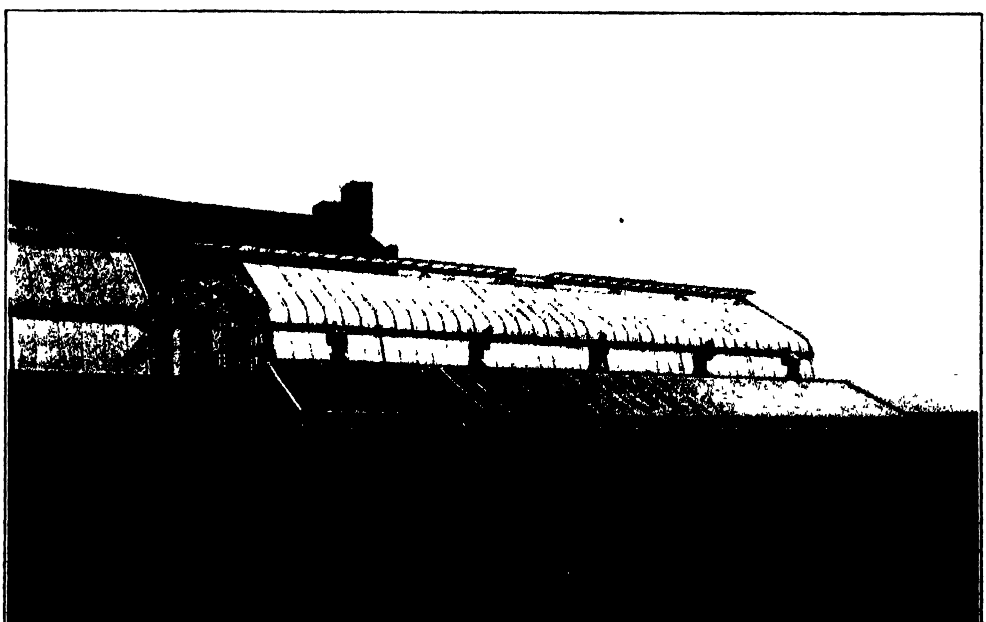
In connection with the study of diseases, much work is being done to develop effective fungicides and insecticides. A sulphur compound has been secured which has proved to be most effective in controlling such pests as codling moth, leaf roller, apple scab, etc. The process for securing it has been improved so that it can be manufactured

in large quantities and thus be made available for extensive use.

It is recognized that the destruction of the infecting organisms is not the final stage in the control of plant diseases, but rather a temporary stage until disease-resistant races of our plants are developed. To prevent the spread of disease by the destruction of infecting organisms is a temporary goal, but to secure immune races of our important plants is the final goal.

Much work has also been done in secured seed sterilizers that will insure seeds against infection which has often resulted in the failure of crops. The problem is to secure a sterilizer that will kill fungi and bacteria, without injuring the seed or plant.

The foregoing very general statement may leave the impression that the institute is more concerned with practical problems than with fundamental investigation. Such an impression should be corrected. The two organizations heretofore engaged in plant research have been the United States Department of Agriculture and the universities. Investigators in the Department of Agriculture frequently state that they are not permitted to go far enough into the fundamentals of the problems they are dealing with. Congress is always demanding immediate practical results, and to meet this demand the fundamentals too often have to be neglected. The same is true of state universities, for the state legislatures are always emphasizing the need of practical results from their appropriations. The Boyce Thompson Institute is dealing with both the fundamentals and the practical and is trying to meet both the scientific need and the public demand. Of course many of the fundamental investigations being carried on do not promise to be of value in practical application, but result in increasing knowledge of the laws of plant develop-



SPECTRAL-GLASS GREENHOUSES.

ment. To understand the plant is the main purpose, and to use some of our knowledge in the handling of plants is merely a corollary. The atmosphere of investigation at the institute does not feel the continual urge of application. It is realized that the more fundamental the investigation, the wider may be its possible application. Practice is merely the superficial application of some of our knowledge. There can be no conflict between fundamental investigation and practical application. In fact, they are of mutual service in the progress of knowledge. Botany is especially well adapted to develop this joint attack upon its problems.

It should be realized that the institute is continually urging caution as to the practical value of its results. Results secured in a laboratory may not prove practical on a large production scale. The program, therefore, is first to conduct investigation in the laboratory under controlled conditions; then to try out the promising results on a small field basis; and, finally, if successful thus far, to extend the application to the large production basis.

PARROTS AT HOME[1]

By ALEXANDER WETMORE
ASSISTANT SECRETARY, SMITHSONIAN INSTITUTION

PARROTS are displayed in zoos in such number and variety that as a group they are probably better known in captivity than any other order of birds, with the possible exception of pigeons. Many persons keep captive parrots as pets at home, and a zoo without parrots would be a curious place indeed. The popularity of these birds is due to the ability of some kinds to imitate human speech, and also to their great length of life as compared with that of most other captive forms. It is not unusual for parrots to live in health for twenty or thirty years, and there is in the National Zoological Park a beautiful sulphur-crested cockatoo that was brought to the park when it was first established in 1890. It was then a mature bird of unknown age, and is to-day in perfect health after thirty-five years as a friend of the public. It is the oldest animal in the collection. Such birds have been known to reach an age of eighty years.

Though savage tribes living in the warmer parts of the earth almost universally keep living parrots as pets, these birds did not become well known in Europe until the time of the Roman conquests. They were common in Rome during the period of the Roman Empire but then practically disappeared until the voyages of exploration began in the fifteenth century of the present era. Since the opening of the nineteenth century parrots have become widely known, and for many years have been imported into this country in large numbers.

[1] One of the series of Radio Nature Talks from the National Zoological Park, arranged by Mr. Austin H. Clark; broadcasted from Station WRC, Washington, December 26, 1925. The illustrations are by courtesy of the National Zoological Park.

In the entire world there are nearly six hundred different kinds of parrots, which are usually divided into two groups, the parrots and cockatoos proper, and the lories. As a group parrots are easily recognized by their heavy bodies, short necks, round heads, small eyes and strong, heavily hooked bills. Their bodies are covered with firm feathers that are usually bright in color. Green is the most common shade in their plumage, often variegated with red, yellow, orange, blue or black. Many are gorgeously marked.

In spite of their bright coloration parrots are often difficult to see. I recall very well, while in a jungle swamp in eastern Porto Rico, a flock of a dozen parrots that swept into a tree twenty yards away, saw me and immediately became motionless so that they seemed utterly to disappear. After ten minutes of careful watching I was able to make out the outline of the head of one bird, but of its colors I could distinguish nothing amid the green of the foliage. Frequently in other parts of the world I have had flocks of parrots fly into a tree above me and then fly away before I was able to distinguish a single individual.

The legs of parrots are short and the feet, like those of a woodpecker, have two toes directed forward and two behind. The upper part of the bill is attached to the skull by a hinged joint that allows free movement up and down, and frequently has a rough surface like that of a file on the inside at the tip, that assists in holding seeds so that they may be cracked and the kernel extracted.

The tongue in ordinary parrots has a soft cushion at the tip, controlled by muscles so arranged that it is freely

THE BLUE AND YELLOW MACAW.

THE GREAT RED-CRESTED COCKATOO.

flexible and serves as a finger to assist in holding and extracting food. The lories have the edge of the tongue fringed with fine filaments so that it resembles a brush. With this they extract nectar from flowers or eat soft juicy fruits.

It is a wide-spread superstition that to enable a parrot to "talk" (in imitation of human speech) it is necessary to split the tongue. This, however, has no foundation in fact, and when practiced only inflicts an unnecessary cruelty. Birds make sounds in a little organ known as the syrinx at the lower end of the trachea or windpipe, and as the tongue has little to do with the process, splitting it has no connection whatever with the ability to imitate sounds.

The calls of parrots living in freedom are as harsh as those that greet our ears in the bird house at the zoo, but are not so disagreeable, since they are usually softened by distance. When feeding parrots are quiet but in flight the larger kinds are very noisy and the approach of flying flocks is heralded long in advance by their strident cries. The smaller species are much afraid of hawks and if feeding in the open fly out with great clamor at any alarm. In the Chaco of South America I found the monk parrakeet in great flocks that fed on the ground in old fields of mandioca and sweet potato and at the passing shadow of every buzzard rose to circle with shrill cries. These birds were much afraid of storms, and when lightning flashed, even below the horizon, the parrakeets were restless and uneasy.

Most parrots lay their white eggs in cavities in trees, where their young are free from danger, but a few vary from

this habit. In southern South America the monk parrakeet joins in bands that build in company a structure of sticks that forms a veritable apartment house in which each pair of birds lives in a separate cavity. These communal nests are used year after year and often grow steadily in bulk. I have seen several that were six or eight feet in diameter and contained enough sticks and twigs to fill a wagon. In early days in the Pampas these birds nested in the low trees that formed occasional groves on the plains. Man introduced eucalyptus trees which grow to a great height, and now the monk parrakeets build nests in the branches of these trees often sixty or eighty feet from the ground. A species of duck known as the tree teal, somewhat similar to our green-winged teal, preempts a chamber in this same communal structure, lines it with soft down, and hatches its own young amid the noisy chatter of its companions. I never became wholly accustomed to the strange sight of these little ducks standing on one leg asleep on some dead tree limb fifty feet from the earth in the vicinity of their nests. When hatched the young ducklings are supposed to tumble out and fall to the ground, where they alight without injury because of their slight weight. I have seen a mother duck on the ground leading her young to water, but was never fortunate enough to observe them leaving the nest.

Parrots are distinctly creatures of habit and follow a regular routine of daily life. The smaller kinds often resort to holes in trees to roost or for that purpose gather amid dense protecting branches. When sleeping some species hang in close bunches by the bill or feet, while others perch on branches like other birds. Parrots do not leave their roost until the sun has warmed the air and dispelled the damp morning chill that is felt even in the tropics, and then in flocks or in pairs they fly out in search of food. Late in the forenoon they fly to water to drink and then feed or rest for the remainder of the day. Their habit of flying to some drinking place is so well known that on one occasion in an arid desert section in Mendoza, Argentina, I followed the flight of a flock of parrakeets for nearly two miles to an alkaline pool where I was able to quench my own thirst.

Although the parrots as a group are so remarkable for the regularity of their daily routine, it is among them that we find one of the most extraordinary cases of the adoption of a new habit known anywhere in the animal kingdom. Those who are familiar with the zoo in Washington may recall an outdoor cage near the bird house in which are several large dull-colored parrots. These are the keas, which come from the hills of New Zealand. The keas are often quiet during the day, but toward dusk or in stormy weather, especially during the colder season, they become very active. At such times their shrill, drawn-out cry, which resembles the syllables of their name, resounds throughout that part of the park. They are playful and mischievous and delight in cutting up logs of soft decaying wood, or in plugging with sticks the drain in their cement water pool.

In their native home in South Island, New Zealand, they are found in the mountains, descending to lower elevations in the winter. With the coming of the white man keas came to feed upon scraps of meat thrown out about camps and houses, or to pull bits of fat or flesh from sheep skins hung out in the air to dry. From this they learned to attack living sheep. Several will alight on the back of a sheep and with their long sharp bills tear apart the wool and skin to reach the delicious fat over the kidneys. This, of course, kills the sheep. Occasionally the birds even attack horses. It has been reported that as many as two hundred sheep have been killed from one flock in the course of a single night

and in some districts the keas finally became so destructive that sheep could not be raised where these parrots were common. Settlers placed a price on the heads of the birds and so reduced their numbers. In 1922 keas were reported as still plentiful in the upland regions. It is from this section that the birds exhibited have come.

Though parrots are commonly considered tropical birds, a few kinds range into colder regions. The barranca parrot of Argentina, which nests in a hole dug in the face of some cut bank above a stream or dry arroyo, is found throughout Patagonia to the Straits of Magellan, where snow and sleet may come in any month of the year, and summer is far from the season of warm weather that we experience in more temperate areas. Another species of parrot is found in forests in the same region. Parrots and penguins seem opposites in range yet it is possible to see the two in close proximity along the shores of the ocean channels of southern Patagonia. In the Macquarrie Islands, beyond Australia, in Latitude 55° South, there is also a parrot, which lives amid such bleak, inhospitable surroundings that we may well wonder how the bird became originally established there.

In North America, too, there are parrots that do not fear the cold. In the early history of our own country the Carolina paroquet, a small parrot about twelve and one half inches in length, with orange and yellow markings on the head and neck and the rest of the plumage bright green, was found throughout most of the eastern United States north to Maryland, the Great Lakes Region and Nebraska, where it ranged in flocks that at times wandered even farther north. Originally these birds lived on the seeds and fruits of various trees, thistles and cockle-burs. With increased settlement they came to fruit orchards and fields where their destructiveness, coupled with their bright colors and noisy habits, led to their extermination by shooting over wide areas. It is supposed that a few persist still in the depths of cypress swamps in parts of Florida, as every year they are reported there by deer and turkey hunters. None has been found by naturalists since 1906 so that they are now very rare. In 1917, on the Gulf Coast of Texas, I was told of some bright green birds with yellow and orange in the plumage that had come to feed on China berries at a ranch near the mouth of the Brazos River. It is possible that the paroquet still exists in the swamps of that region.

In this connection I may note that recently I have identified an extinct cousin of the Carolina paroquet in a fossil state from northwestern Nebraska from bones that are supposed to be two million years old.

In northern Mexico there is a larger parrot with a long tail known as the thick-billed parrot that feeds on the cones of pines and on acorns. At irregular intervals this bird comes north across our border into the Chiricahua, Huachuca and Graham Mountains, and other nearby ranges, in southern Arizona, where it may remain in flocks for a year or more before it disappears. On occasion some have been captured alive, and we have had them in former years displayed in the bird-house at the zoo. In its native home in Mexico the thick-billed parrot ranges in forests of pines and oaks in the same areas as the imperial woodpecker, a wonderful bird as large as a crow. These two species have a curious relation to one another, as the parrot uses the old nesting holes of the woodpecker, cut in the trunks of trees, as a home for its own family where it may rear its young in snug protection from the elements.

In connection with the thick-billed parrot it may be noted that they have been long known in captivity. Mr. Neil

M. Judd, of the National Museum, who for five years has had charge of the work of excavation of the ancient Indian village site at Pueblo Bonito, New Mexico, has found there bones of many birds. Among these I have identified bones of the thick-billed parrot, together with the military macaw, the red, blue and yellow macaw, and the white-fronted parrot of Mexico. We suppose that these birds were brought from the south through channels of trade and barter among the Indians.

Many Indians eat the flesh of parrots regularly and when in camp where meat was scarce I have on various occasions eaten them myself and have found them as palatable as pigeons. Cooked with rice, their bodies formed the basis of many a dinner. They were considered a great table delicacy in the days of the Roman Empire, and it is said that one Roman Emperor imported parrots to feed to his captive lions.

Though similar in general appearance parrots vary greatly in size, from little love-birds, smaller than a sparrow, to giant macaws three feet long with huge bills as large as tea-cups. Their habits vary as widely. Much time might be consumed in relating strange traits, but with this brief review I must conclude my account.

HUNTING BIGHORN WITH A CAMERA

By DR. VERNON KELLOGG

NATIONAL RESEARCH COUNCIL

THE Rocky Mountain sheep, or bighorn, is one of the most extraordinary and interesting of American animals. It is not limited to the Rocky Mountains, but varieties of it are found also in the Sierra Nevada and in the mountains of Alaska and Mexico. In earlier years it was a great favorite of big-game hunters but is now protected by game laws.

As a boy interested in natural history I had read all that I could find written about the bighorn. Especially had I soaked up all the stories about its wonderful surefootedness, its marvelous speed over rough rocks, and, most thrilling of all, its alleged habit, when closely pressed, of leaping headfirst over high sheer precipices and landing on its great strong curved horns. Of course, only the males, and the old males at that, have the big horns, so that the ewes and young would not be able to follow the head of the family in this wild leap for liberty. Rather selfish of father, it would seem, to desert the family this way. But he had this good excuse. The hunter was really after father and that pair of big horns for a trophy, and was likely to let mother and the kids alone—unless, unfortunately, he was hunting for meat and not glory.

When I got to college and began to study natural history seriously I still remembered the stories about the bighorn, and kept an eye out for a chance to get to Colorado and into the Rockies to see these interesting animals in their rocky fastnesses far up among the great peaks. Also, as I lived in Kansas, which, whatever else it has in the way of scenery—and that isn't much—has no mountains at all, I wanted to see mountains, high mountains and deep canyons, with great silent forests of spruce and pine and swift clear mountain streams with trout in them. I wanted to camp and climb and see bear and elk and deer—and bighorn.

So five or six of us college mates figured out very carefully what it would cost to spend a summer in the Colorado Rockies. We had to figure carefully, for we were all poor, and our families thought they were doing enough to support us in college without grub-staking us for an expedition after bear and bighorn in Colorado. We decided that we could live chiefly on flapjacks, trout, bear-meat and wild red raspberries, of which menu only the flapjacks would cost us anything. The rest of the food we would find in the mountains. We would do our traveling on foot, after once getting to Colorado, with perhaps a burro or two to help carry our packs. In addition to our guns and trout rods we would take cameras, and I, at least, registered a solemn vow that I should hunt bighorn, if not with a gun, which was prohibited by law, at any rate with a camera. And I may say right now, based on considerable experience, that hunting wild animals with a camera is no less exciting than hunting them with a rifle, and requires not less, but more, skill and persistence.

Our little group of Kansas college freshmen was composed of chaps who had some stuff in them. There was Fred Funston, who later fought in the Philippines, captured Aguinaldo and became a major-general in the U. S. Army; Her-

bert Hadley, who became governor of Missouri, and only narrowly missed being nominated for president by the Progressive Republican party in the days of Roosevelt; William Allen White, now a well-known editor, author and publicist; and two brothers, named Franklin, one of whom has become an eminent chemist and the other as eminent a mathematician and physicist. But at the time of our trip after bighorn we were all as green as Kansas corn in a good summer, and perfect tenderfeet as far as camping, climbing mountains and hunting big game were concerned.

But I must get along to the bighorn. We made headquarters camp in a beautiful little, high-level, glacial valley in the Front Range of the Colorado Rockies, and started our climbing by getting to the top of Long's Peak, 14,255 feet in altitude, and one of the highest, most difficult and dangerous of the Colorado peaks. After that we did all the other peaks in the vicinity. It was great sport —and always with the tang in it of a little danger. Funston and I once got caught in a violent snowstorm on top of an especially rough peak. The snow changed to sleet while we were out in the middle of a great snowfield which lay at a steep angle on the mountain flank and simply had to be crossed in order to get down to timberline from the summit. The surface of the field became like ice, and we could only move over it by breaking through the crust for each footstep. It was very dangerous going, for once started on a slide we couldn't possibly have stopped until we got to the bottom of the field, which was at least a thousand feet below, and margined by a rampart of rock against which we would have dashed at terrific speed. But we made a special point of not slipping—and didn't!

After we had cleaned up all the near-by mountains, in the course of which we saw many signs of bighorn—especially their many narrow little trails cut three or four inches deep along the mountain flanks well above timberline, but none of the animals themselves—we learned from an old hunter and trapper, who lived alone in a rough cabin not far from our camp, that while the wild sheep used to be plentiful in the near-by mountains and still were to be found there occasionally, more of them could be found in the high mountain country farther north toward the Wyoming line. So we packed up Billy the Burro to the limit of his capacity to carry things, put the rest of the camping outfit on our own backs and started north. We picked up trails when we could find any, but mostly we just headed north. For much of our way we worked along the flank of the range above timberline, to which we had to come down at night to make our campfire for cooking and keeping warm. We had been told of a long extinct volcanic crater called Specimen Mountain to which the bighorn were reputed to come from long distances away in order to lick on the green and yellow beds in the crater bottom. This was our goal.

On our way we started up a rather small bear and chased it into a hole in a great rock pile. How to get it out? After sitting around the hole for a while, without working out a satisfactory way, Funston finally suggested this interesting plan. He volunteered to crawl into the hole and stir up the bear, which would presumably get angry and chase him out. The rest of us were to stand by the side of the hole and shoot at the *second* object to come out; the first one Funston fondly expected would be himself. This plan seemed reasonable, but on careful consideration we vetoed it; there seemed to be just a chance that nothing at all might come out of the hole, not even the future capturer of Aguinaldo himself.

Finally we arrived near Specimen Mountain and established camp in a beautiful high level pass only a little below timberline. This pass was really part of the Continental Divide, for the water which flowed down from one side of it was carried into the North Platte, thence into the Missouri, the Mississippi and finally into the Gulf of Mexico, while the water from the other side, only a hundred yards away, flowed into the Grand River and thence by the Colorado River into the Gulf of Lower California. There was plenty of water and firewood, and by scrambling down a thousand feet to the Grand we could get all the trout we could eat. It was a fine camp. We were now ready for bighorn.

Excitement soon came, although at first not from bighorn. One of the boys had left camp with a shotgun soon after we had got things in order, a cooking place fixed up with stones, level places found on which to spread out our bed blankets, and our flapjack flour, sugar and salt under cover of a rubber poncho. The hunter had gone forth to try to find a blue grouse or two for supper. His shotgun shells were loaded with large birdshot. Just at dusk he came back madly running and calling for help.

It seemed that in his wandering he had discovered a little bear cub, and, like the proper tenderfoot that he was, had sent a load of birdshot at it. The cub was not much hurt, but enough to stimulate it to a loud squealing which had brought an angry mother bear to the rescue. There was nothing for the brave hunter to do but to start for camp with all possible speed, which he did, without hesitation and with no glances backward. One sight of mother bear had been enough. It was, according to the hunter, probably the largest grizzly bear that had ever existed in the Colorado Rockies! Fortunately for our indiscreet hunter—and for us—mother bear did not follow him to camp, but turned back to her cub.

And now came the bighorn. Literally that. For as we busied ourselves with cooking supper, and further fixing up of camp, we were startled by a sudden noise and looking up were more startled to see half a dozen bighorn charging down the mountain slope just behind us and directly toward us. They dashed right through our camp, swerving only a few yards to one side as they saw us and our little fire. It was breath-taking.

We found next morning that we had chosen for camp site a spot over which a number of bighorn trails ran from Specimen Mountain on the north down the slope across the little meadow on the pass and up the next mountain of the range to the south. So rarely visited was this region that the bighorn, with all their wariness, were not sufficiently startled by our presence to leave their regular trail by more than a few yards. However, no more such surprising visits occurred.

Next morning we set out and up on a reconnaissance and found that above timberline, which was only a few hundred feet higher than our camp, the steep slope of the old volcano was smooth and easy to climb. It led us directly up to the rim which ran evenly and almost completely around the great crater. Thus we could easily walk all around the crater, keeping just low enough below the rim on the outside to prevent any animals within the crater from seeing us. But it was easy for us to see the inside of the whole crater by merely crawling carefully up to the rim, and lifting our heads slowly up high enough for us to peer over the crater's edge.

The inside of the crater presented a remarkable sight. The bottom and walls were composed of old ashes and scoriae with some cliffs of shining basalt and numerous upstanding castles and pin-

nacles of braccia or volcanic conglomerate. Some of these stood up fifty or sixty feet from the floor or side walls of the crater and were twenty or thirty feet wide.

As we cautiously looked over the rim we were gratified to see a group of bighorn resting quietly on a sort of basalt platform jutting out from the crater wall. Two or three were lying down, two or three more were moving slowly about, while on a higher part of the platform was a fine old male with tremendous curved horns, standing rigid and alert, evidently the lookout for the band. We watched them admiringly for a few moments, when unluckily one of us, in trying to change position, pushed over the rim a loose stone which bounded down the inside of the crater.

Like a flash every sheep was on its feet and on the *qui vive*. Because we kept perfectly motionless, the big lookout could not be sure, for a moment, where we were, but taking his cue from the direction of the bounding stone he started up the precipitous side of the crater away from us, followed closely by all the others. It was a beautiful sight; their ease and confidence in swiftly getting over the rough steep going was impressive. In a few moments they were out of the crater, and, heading north along the mountain's upper flanks, they soon disappeared from our view. But we had seen bighorn close at hand, although too far for photographing, and felt that their fright had not been great. They would come back.

After they had gone, and we could stand up and move around the rim and survey the whole of the crater, I worked out a plan which I felt sure would result, if everything went according to plan, in getting some bighorn close-ups.

The plan was very simple and was suggested by the two facts, first, that one could move all around the rim, out of sight, and then come into sight wherever desirable, and second, that the great breccia castles ought to give one sufficient protection from being seen to allow one to work down into the crater, keeping one of these castles between one and any band of sheep that might be anywhere in the crater. Of course the wind would also have to be right—that is, blowing from the bighorn toward the stalker and not from the stalker toward the bighorn. They have a perfect sense of smell.

So the next day we all went up together again and, on peering over the rim, were wildly excited to see a band of nearly thirty bighorn in the very bottom of the crater. Almost between them and us towered a great breccia castle. The wind was just right to allow me to try to get down the crater wall behind the castle.

I began a hard and wearisome descent of nearly two hours, slowly crawling over sharp bits of basalt, rough blocks of conglomerate and beds of old ashes, keeping always that protecting breccia castle between the animals and me.

I finally got down to the base of the castle. This was as far as I could go. I was within a hundred yards of the band of bighorn, which had all fortunately kept close together. Behind the castle I waved a handkerchief to my carefully watching companions on the rim above, who immediately set off below the rim on the outside to a point just opposite where I had gone down. They were to scatter a little there, and then all to show themselves at once on the rim to frighten the sheep towards me.

It worked. I was ready with camera already pointed to that side of the castle which seemed the most likely to be chosen by the sheep in their flight.

I heard a clattering of hoofs and rocks. The noise grew louder. My companions added violent yells to be sure that I

knew the sheep were coming. I did know it. I couldn't help knowing it. I was growing violently excited. I held the camera at a ready angle. And then that magnificent band, led by two superbly-horned old males, dashed around the side of the castle, bearing directly toward me. I thought they would run over me. But they didn't. They swerved slightly and there they were, all lined up, broadside on, only twenty yards away. It was a picture made to order.

But, alas, it was too exciting. I had a bad case of buck fever. My hands jumped as the sheep did. I couldn't hold the camera still. It was no use. But I did manage to press the bulb.

That negative when developed and printed from yielded a picture of bighorn at close range. But every sheep in it is a blurred something with a dozen legs. No naturalist would recognize the animals on it. He would think they were centipedes. But I recognize them. It is my prize picture.

THE PROGRESS OF PUBLIC HEALTH IN CHINA

By Dr. REGINALD M. ATWATER
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A FEW months ago I was asked to vaccinate several hundred children against smallpox in a large but old-fashioned public workhouse located in a provincial capital of China. While there I saw a small beggar boy with badly infected eyes and cheeks stained a bright red color. He had been treated in a local mission hospital with a new germicide specially useful in such cases and by the aid of which his vision was saved. Less than five years before, the discovery of this special drug had been announced at a research institute on the other side of the globe from China and after prolonged study of this and related chemicals. In this short period of time its use had not only spread across the intervening miles of land and water and across national and racial barriers, but it had been made available to him, a penniless and homeless lad, through the aid of well-placed philanthropy.

This incident epitomizes to me some of the progress that scientific medicine and public health have made in China. It is not yet general over China, nor is the movement yet sufficiently indigenous, yet the growth in sentiment is a real thing.

A true perspective in the development of public health is indeed difficult of attainment in this day and age. It would be difficult to devise a method for getting a true perspective better than that open to the student of public health who lives in China and sees there the attitudes and methods which were a part of the lives of our own ancestors. One comes to a fresh appreciation of the heritage that is ours in this favored land. China's present slight regard for matters of public health may be compared to that of the makers of our own Constitution. It never occurred to these American fathers to include provisions for the federal control of health work, provisions which are now a part of all modern constitutions, and we should not be too hasty in requiring attention to these facts from the Chinese.

There is a well-known Chinese classical book on disease, the Shang Han Lun, written at about the beginning of the Christian era, and a book still commonly bought and read for its supposed value in treatment of diseases of to-day. This book is venerated because it is old and tried. It is not possessed of our much-admired newness or scientific accuracy. It is built on the classical and empirical methods of the old physicians. Between this book and a modern treatise on scientific medicine there is a gap scarcely to be bridged by one generation of Chinese, but the progress along this road is promising and apparent as well to one who has lived among the Chinese people.

It would seem appropriate to speak at this point of the much-quoted custom among Chinese of paying the doctor to keep the patient well and not paying him when the patient becomes ill. It would be interesting to know the origin of this report, for diligent search in China does not reveal any knowledge of the practice among the Chinese and nowhere is there evidence that the Chinese physicians have emphasized prevention of disease at all.

In enumerating those agencies which are promoting the public health in China to-day we may mention certain official bureaus of the government, such as the Manchurian plague prevention bureau and the epidemic prevention

bureau in Peking. Both of these agencies have grown out of the effort made in 1911 to stem the tide of pneumonic plague that threatened all central Asia, and at present they are making some progress, though the present areas where plague is endemic are left out of account. Sera and vaccines are now being produced in Peking under good auspices and a healthy growth has characterized the past few years. The national code of laws of the republic has some provisions for control of medical practise, but these are purely nominal at the present time and can not be said to do any good. Several Chinese cities have police health officers, so called, but these men almost without exception have not contributed anything, for they are untrained and ignorant of the best methods. One progressive city recently appointed a first-class, western-trained Chinese physician as health officer, but the political situation was such that his tenure of office was short and his work fruitless. And this is about all we can say for the official agencies.

There are some voluntary agencies which are promoting the public health, like the few good medical schools, a number of hospitals, which are becoming centers for the propagation of health ideas, and a modern health center in Peking. This latter is nominally maintained by the government and is a splendid experiment in adapting the preventive idea to China's needs. There is a Council on Health Education in Shanghai and there has been a Committee of the China Medical Association, both of which have aided the translation of scientific material on hygiene as well as the preparation of health propaganda material.

In connection with these voluntary agencies there may be noted several active health associations in the larger cities, some of which have paper programs as diversified as one of our western cities would have. There have been some interesting studies made in sewage disposal methods, in the distribution and control of hookworm disease, on schistosomiasis, on kala azar and in the development of useful drugs from the old Chinese pharmacopoeia. Advances in school and community hygiene, in educational hygiene and in health propaganda work of several sorts have been made by the Council on Health Education.

Famine and poor relief are not public health measures in the United States, but in China they are necessary directions of effort which take precedence over more refined measures for combatting the force of mortality. Of particular interest is a movement in Hunan Province which has sought to greatly improve the existing public measures for poor relief. Through the enlightened interest of one Chinese gentleman, methods have been so changed as to meet this problem in a fairly satisfactory way and his idea is being copied widely. The relief of poverty is indeed the keystone in the arch of public health.

To enumerate the contemporary agencies which are defeating the aim of public health will require a longer list. Most people would place governmental instability at the top of the list. To this must be added the militarism everywhere found, with its associated brigandage, wars, disorders, poverty, famine and the opium evil. The margin between the supply and the demand for food is very narrow and the actual famines which result from drought and floods are frequent and severe. The associated typhus and relapsing fevers and other pestilences that go with famine take their large toll of life.

The newer developments of industry in the large centers are bringing in laborers from the country who often have to live under deplorable conditions of sanitation. Hours of work are very long and work every day in the week is the rule. Child labor and the labor of

women are widely exploited. The nation is being pauperized in those elements of physical and mental well-being so essential to-day in the young and in women, who are the centers of family life. There is a total absence of maritime or border quarantine which conceivably might prevent the importation of exotic disease, and no semblance of a national census, which is such an essential link in any public health organization. The scarcity of hospitals of all kinds and the almost complete absence of tuberculosis sanatoria is a serious obstacle for both the present and the near future.

But perhaps the most significant of all obstacles is the inertia that comes from the firm adherence of these hundreds of millions of people to traditions which have been their heritage through thousands of years. These traditions in their time have been elements of great strength and have provided a racial solidarity that is scarcely matched in human annals. But the dependence of the masses on worthless measures for the preservation of health, the wide prevalence of ideas of disease which are demoniacal or worse, veneration of the old because it is old rather than because it is good, general distrust of the new because it is new, failure to understand or to profit by the scientific method, adherence to outworn usages and a fatal tendency to laissez-faire—these are the real obstacles to public health progress in China to-day.

Thus frankly stating the favorable and the unfavorable elements in the situation, just as we would wish Chinese to do in appraising our own conditions, we can see that ultimate success for public health will depend on adjustments in intellectual matters, on changes in governmental method, in commercial adaptations, in educational advancement and on changes in countless other aspects of human life. The very complexity of the situation challenges the interest of those who feel that the welfare of the whole race demands the welfare of China.

While it is true to say that governmental instability stands at the top of the causes which operate against public health, the more significant force is still the underlying continuity of the great stream of human life in the Middle Kingdom. Life in China goes on day by day and year by year largely unaffected by transient military and political conditions which would be serious complications in our life here. I found this true when I lived in a city of central China which was besieged for six weeks. During this time the city frequently changed hands and was in the zone of almost constant fighting. Yet the current of daily life was not seriously disturbed. Schools, colleges and business went on largely uninfluenced by the fact that shots and shells were flying overhead most of the time. The people took practically no interest in the struggle except enough to keep them from being involved in the difficulties. So to attain a true insight into the possibilities for public health in China we must to a certain extent overlook the surface disturbances of government that overhang most of these members of the yellow race and focus our attention on the broad current of human life which goes on under the surface storms and which so much needs improvement in healthful ways of living.

There is a different background for public health sentiment in the Chinese race and in our western make-up. Chinese do not spontaneously resent inroads on personal liberty as we all do here. Anti-vaccination sentiment is hard to raise among Chinese, particularly among people who depend directly on the life-preserving quality of vaccination. Toward certain racial poisons they have very different attitudes from ours. The overuse of alcohol is not common in China, even though unlimited access to alcohol is afforded to every one. Indul-

gence in opium, on the other hand, is more easily acquired by the Chinese race than by some other races. The whole background of sewage disposal in west and east is utterly different. Here sewage accumulations are a liability to the individual, who pays either directly or indirectly for their removal and destruction and who pays generously for methods which permanently remove this material from sight and smell. In China, on the other hand, the accumulation of excreta is an asset to the householder, who expects to receive payment for it, expects it to be used for fertilizing purposes and who is not seriously distressed by the sight or odor connected with the process of removal. If then we expect China to install water-carriage disposal of its sewage on the same plan as American cities, we do not count on very significant differences in the western and the Chinese situation.

There are also racial susceptibilities worth pointing out. Chinese who live where vital statistics are kept are known to suffer from respiratory and circulatory diseases more frequently than the Caucasian race. Thus in 1921 in the United States the comparative rates were as follows:

	Chinese in U. S. A.	Caucasians
Death-rates from all causes (per 1,000)	24.47	11.20
Tuberculosis (per 100,000)	526.3	85.3
Circulatory diseases	332.8	182.0
Respiratory diseases	238.8	102.8

While these figures may be subject to slight correction for differences in age distribution, the facts in the main are as indicated. Chinese very rarely have certain of the metabolic disorders, like diabetes, and it is believed that they have a racial immunity to diphtheria of relatively high degree, as do certain other races with pigmented skin. Chinese live on a lower level of blood pressure than we and rarely suffer from hypertension. They have a lower level of basal metabolism which may be associated with their easier way of life.

Thus there are known physiological differences which tend to alter disease prevalence and the methods of control must therefore be properly adjusted. These very differences between us and the Chinese may easily prove to be keys for the better understanding of some of our own chronic diseases. With the mention of these differences in background and method it is clear that in China there is the same public health goal to be achieved, but the successful approach to that goal will be different in some respects from that here.

One might speak indefinitely of the numerous differences between aspects of life in China and the west. After all, these differences are more apparent than real and more superficial than fundamental.

Two men in middle life, fathers of families, die from typhoid fever, one in China and one in America. At the funeral in China the mourning color throughout is white, while here it is black. The hearse is bright red there and black here. The music—there could scarcely be any greater difference between the music played at the Chinese funeral and that used here. Firecrackers will mark the occasion there while prayers will be said here—every aspect of the occasion will be marked by differences equally as great as those mentioned. Yet, beneath the ceremonies there and here is the same overwhelming grief to the wife and family, the same loss of educational and economic values to the community, the same dangers to those who have been associated with this perilous infection and the same preventable disease is responsible. There are no differences in the parasite that killed the two men; it enters and leaves the body in just the same ways, it spreads through similar channels, it damages the constitution of Chinese and

American in exactly the same fashion. The outward aspects of the two are very different. Looking more deeply we see their essential similarity and we realize that, when all is said, the resemblances of the two incidents are greater than the differences. Human nature and disease are much the same the world over: "The Colonel's lady and Judy O'Grady are sisters under their skin."

We might set down some of the diseases which are specially prevalent in China and which the rest of the world can well do without: plague, both bubonic and pneumonic; schistosomiasis; kala azar; clonorchiasis; relapsing fever; typhus fever; cholera; rinderpest; foot and mouth disease; severe smallpox; sprue; amoebiasis; leprosy and beriberi.

To make the list fair we should add certain of the diseases of the rest of the world which China does not have as we do and which she can well do without: yellow fever; Rocky Mountain spotted fever; poliomyelitis; pneumococcus pneumonia; pellagra; tularemia; dengue; trypanosomiasis, and we have already mentioned the rarity of such conditions as diabetes and high blood pressure.

It has often been stated that China is the ancient home of diseases like plague, cholera and influenza, which at certain times have spread to the rest of the world. The 1894 plague outbreak, the immediate precursor of the present pandemic of plague, did first come to notice in China. But usually it has been our ignorance of the real source of epidemics which has led us to assign their origin to those parts of the world where the prevalence of disease is least understood. There is, however, sound justification for the modern effort to track disease down to the places where it smoulders and, until China's health is made secure, the health of the rest of the world is in peril from China.

China can not be said at the moment to be progressive in directions which improve public health. One ought to note certain encouraging elements in the situation which portend a better day.

There is being created now in China a small but very influential body of well-trained physicians who are acquiring the idea of prevention along with other concepts of modern medicine. In this nucleus is the great promise of the future. These are the men who, with the facts of science, must make the adaptations of these facts to life in China and we must allow them freedom in adjusting these methods to conditions as they find them.

Among these Chinese medical men there are some to whom the preventive idea just naturally appeals. President Vincent has pointed out that this same thing is increasingly true in the United States. These peculiar men love to deal with humanity in the large; disease as a mass phenomenon appeals to them tremendously; they like social problems involving cities, provinces and nations; these men someway prefer a salary rather than the uncertain collections of private practice, and some of them have faced the difficult decision and have chosen the laboratory instead of the limousine—or we might say, have chosen the ricksha instead of the automobile. Foolish as it may seem, these men simply can't be kept from doing this type of public service, for they are endowed with sufficient imagination to see that there are significant values in preventing disease and death, even if they can not tell the names of those whose lives and health have been saved, a difficulty inherent in preventive work as against curative medicine.

To a large extent, the problem of public health in China is bound up with the application of known facts to human life. It is not primarily abstract research that is needed, but the study of social applications of the facts already known and it is reasonable to anticipate

large returns on investments in this direction.

There has been a decided improvement in the recognition accorded to scientific medicine in some of the areas longest open to modern medicine, now nearly a hundred years. One city has about 350 physicians trained in modern methods who are being accepted by the community in generous fashion. In other centers the need is to create an understanding of and a demand for scientific medicine. In a few of the larger cities there have been ventures in the direction of medical education, public health centers and campaigns for health on the part of the government, which are encouraging indications of a growing community interest. There has been progress in the recognition of the fact that gifts from wealthy individuals can play a part in public welfare. Chinese have not yet learned to give to institutions that promote the public welfare, but at least one Chinese merchant has endowed a university with a princely sum and a medical department will be opened here in the near future.

One hopeful line of research is that which seeks to find values in the drugs of the old Chinese school. These old physicians used such drugs as arsenic, mercury, the common cathartics and anthelmintics in blind fashion. Here is a mass of useless chaff and some grain and already out of this study has come one drug, ephedrine, and there are very likely other similar values waiting to be found.

Perhaps the most encouraging feature of all to-day is the rising tide of nationalism which has come to the front so strongly in the past few months. The outbursts of feeling which have occurred recently have frequently flared out against grievances both real and imaginary and the present accounting shows that some of the Chinese have not been too discriminating in their attacks on what has come to China from the west. But the Chinese are in the end a very sensible people who can not fail to recognize real worth when it is properly presented to them and we can hope that they will soon attain an insight which will allow them to preserve the best elements of that which the west offers China. No true friend of China can deplore the rise of this spirit of national pride, however much he may regret certain directions in which the fire has burned beyond reasonable bounds. It is this same spirit which will save China, and national pride will be a strong element in promoting public health reform. In her potentialities China is great and in these possibilities we can find hope for the future.

There was never a time in history when there was so great a disparity of knowledge and attainment in hygiene on the part of contemporary peoples as to-day between the east and the west. There is, therefore, an unprecedented opportunity which gives added point to the effort that is being made for the benefit of China, an effort that has assumed large proportions. In this time when so much can be accomplished by the application of the facts of science to human life, it is highly desirable that the aid to those agencies which are promoting the welfare of a quarter of the human race should be generous and sustained. The work has a self-propagating quality because of the reproductive capacity of the future leaders now chosen for training and the opportunity for unselfish investment of both personality and power in the form of money is very great just now.

To the end that in China as here

> Health may be more perfect,
> Life more vigorous,
> Disease less frequent,
> Decay less rapid
> And death more remote.

POLITICS AND THE PUBLIC HEALTH

By JAMES A. TOBEY

WASHINGTON, D. C.

THE chief problem of modern public health administration in this country is one of personnel. In spite of the fact that this branch of public service offers many fascinating opportunities for constructive effort, it seems impossible to secure an adequate supply of properly trained sanitarians. Medical students, sanitary engineers and other persons presumably well grounded in the fundamental principles underlying sanitary science hesitate to make public health a career. As reasons for their reticence they cite the inadequacy of the compensation, the insecurity of tenure and the fact that partisan politics frequently tends to retard real scientific progress.

For these criticisms there is, unfortunately, some justification. It is true that a competent and successful physician can earn more from the practice of medicine than he could ever hope to draw in salary as a health official. On the other hand, there are some advantages in the career of the successful sanitarian. His regimen of life can be much more regular than that of the doctor of curative medicine, his income is fixed and more or less certain, and his accomplishments are, or should be, more satisfying, for the results of his efforts are measured not by the relief, but by the prevention of disease. Public health means the highest type of public service. The administration of it needs, therefore, the finest kind of practitioner obtainable.

Public health is to-day a definite and distinct science and those who practice in this field are members of an actual profession, a new one, perhaps, but a real one, nevertheless. It is not a branch of medicine, though physicians like to look upon it as such. Nor is it a subdivision of sociology, though social workers make that claim. Neither is it a matter of engineering, though civil and sanitary engineers would have us so believe. It is no one of these but a combination of all of them and of some other branches of scientific knowledge. Public health draws upon preventive medicine, sanitary engineering, chemistry, sociology, economics, statistics, education, law and psychology for its component parts. This may seem fairly broad in its ramifications, but, while complex, it is no superscience. It is, to be sure, no field for the dilettante, but the sanitarian is not required to be a superman. Train the health worker properly and free him from the inhibitions of politics and he will, as a rule, produce results.

Public health, then, is the science and art of disease prevention, health promotion and life prolongation. It deals with man and his environment, both of which are controllable matters. It is based on experience, the accumulated wisdom of a science which has gradually developed from the foundation laid by the great Pasteur in the latter part of the nineteenth century. It has many positive achievements to its credit, though a few pseudo-scientists who have a sort of nodding acquaintance with public health sometimes scoff at these accomplishments and attribute the admitted improvement in national vitality entirely to the biological phenomenon of natural selection. The sanitarian, be-

ing more liberal, concedes that hereditary influences have played their part, but points to the mass of evidence which demonstrates the irrefutable significance of environment on salubrity, public and personal, and he therefore feels justified in demanding his proper share of the credit for lengthening the span of life.

As an instance of the control of the environment, typhoid fever presents a striking example. At the end of the nineteenth century this disease was often epidemic and as late as 1911 was taking an annual toll in this country of about twenty-one deaths per 100,000 population. The sanitary engineer was not only the epidemiologist who demonstrated the mode of infection, but also the eradicator of the disease who built proper sewage disposal plants and constructed devices to produce and maintain pure and potable water supplies. Thus, to-day the death-rate from typhoid fever has been reduced by two thirds, to less than six per 100,000. The sanitary engineer has done the same service with the mosquito-borne diseases, malaria and yellow fever, and has likewise almost banished hookworm from North America. The laboratory worker has developed methods of immunization against diphtheria and, recently, scarlet fever, so that to-day no one will die of these diseases, unless so utterly deluded as to let a chiropractor try to treat them. Tuberculosis is, perhaps, the most remarkable example of the conquest of communicable disease, because twenty years has seen its mortality more than cut in half, from nearly two hundred in 1900 to about ninety in 1922. Many factors, economic as well as sanitary, have undoubtedly contributed to this result, but no small part is due to the efforts of the expert public health worker.

All in all man seems to be getting the best of the microbe. His achievement is, moreover, measured by his skill. This is shown by the fact that conditions vary widely in different parts of the country. The biologist may endeavor sardonically to explain this by variations of race, of climate or of anything but sanitation. His explanations do not hold good in the face of the facts, however. When Berkeley, California, can have an infant mortality rate in 1921 of thirty-nine deaths under one year of age per one thousand live births, while Fall River in the great states-rights-frenzied Commonwealth of Massachusetts has a rate of 114, something other than heredity is to blame, especially when it is considered that New Bedford, a municipality quite similar to Fall River, has a rate nineteen points below the latter's 114. When Minneapolis can attain an infant mortality of fifty-six and certain other cities of similar size do not, again the guilt must fall not on natural selection, or its failure, but on environmental conditions, which are controllable. New York, a conglomeration of diverse nationalities and racial strains, reduced its infant death-rate from one hundred and forty-four in 1908 to eighty-five in 1920.

The factors over which sanitarians have not had so much control, and which any sensible person, except a eugenist, perhaps, will admit have had an effect on public health, comprise such matters as the increased economic independency in this country, with its concomitant improvement in housing, nutrition and medical care; the advantages of better educational facilities, resulting in a more widespread understanding of personal hygiene, though, as Dr. Haven Emerson has appropriately remarked, we know infinitely more than we use; and finally, perhaps, a gradual immunity to certain maladies, brought about by natural selection.

In the last analysis, however, the development of public health gets back to a question of men. The great sanitarians like Gorgas and Sedgwick did great

things because they were the men that they were. Both are dead and at the moment there is no one in their places. Welch and Vaughan and Chapin, who have been among the leaders, have nearly reached the retirement stage and very few are in sight as yet to fill their places. There are only a dozen reputable schools of public health in this country and they do not seem to entice vast numbers of candidates for this attractive career. In 1923 there were graduated from the Harvard School of Public Health, the School of Hygiene and Public Health of Johns Hopkins, the course in biology and public health of the Massachusetts Institute of Technology, the graduate work in public health of the University of Michigan and the public health courses of the Yale School of Medicine, to mention the leading institutions, just sixty-seven persons. The total for all schools of public health in 1923 was eighty. Many of the students in public health at Harvard and Johns Hopkins are induced to go there by scholarship grants from the Rockefeller Foundation, which has endowed these two schools, and a large number of the students in both these institutions are foreigners who return to their own countries after completing their courses. It is estimated that there are at least twenty thousand positions in this country in official or unofficial health work, though, of course, most of them are now occupied by so-called sanitarians.

The type of men and women in these positions are mostly those who have been trained in the school of experience, which is often rather good instruction. Sometimes, however, the training period, where there is no foundation, is a trifle detrimental to the welfare of the public. A recent survey made by the American Public Health Association showed that 7 per cent. of the health officers of seventy-two cities having a population of one hundred thousand or over had received neither college nor professional training. In a list of over seven hundred city health officers, issued by the United States Public Health Service, only ten are noted as having degrees in public health, such as the doctor of public health, or the certificate of public health, though undoubtedly there are others who have been specially trained but are too modest to list such degrees as they may have received. Similar conditions of lack of positive training obtain in state and county health departments. Of course, there are plenty of capable and efficient health officials who have been well educated in the university of hard knocks. There is a goodly number, however, who have not derived any particularly useful erudition along public health lines from this source, who might have been benefited by the proper kind of a college course in sanitary science.

So much for the lack of training. When the tenure of office is examined, it has been discovered by the United States Public Health Service from a recent inquiry that over one half of the state health officers concerning whom the report was made had served less than five years and that of the number now employed over forty per cent. had held their present positions for less than two years. In Texas, for instance, the state health officer changes so frequently that no sanitarian in other parts of the country ever has the slightest idea who is the present incumbent. This is no sarcasm, but is literally true. City health officers are also often short-termed officials and frequently survive only for the duration of an administration and sometimes not that long.

Two factors are involved in this matter of tenure. One is the paucity of the average salary paid to health officers, the other is the baneful influence of politics. The present orgy of economy which, due to the stimulating influence in the nation's capital, is now sweeping the country, is kicking against the pricks

when it comes to expenditures for public health, for they have never in the history of sanitary science been anything but extremely penurious. A study of the budgets of 187 American cities in 1921 showed that the per capita expense for health purposes was only seventy-one cents. For the "promotion of cleanliness," such as street cleaning, rubbish disposal and other similar branches of municipal engineering $2.50 per capita was spent, while $10.62 went into education and $2.57 for fire protection. Naturally, under such conditions, compensation for the official guardians of the public health is not lavish. Three years ago the Committee on Salary Standards of the American Public Health Association recommended that the minimum salary for a state health officer should be $5,000 a year, which is a reasonable figure for the importance of the duties and the preparation and skill required. The actual salary paid averaged only $4,453 for all the states. Economy may be a good thing, but when it comes to a choice of spending many millions for hospital and institutional care of the physically and mentally defective as against thousands of dollars in order to prevent the conditions which call for these relief expenditures of millions, any person with any vestige of intelligence whatsoever ought to be able to realize that the ounce of prevention is worth more than the ton of cure.

Security of tenure has, of course, two sides to it. Tenure should not be so adamantly secure that unqualified persons can remain interminably in office and on account of their unfitness hamper progress in public health work. Health officials should, nevertheless, be allowed to hold their positions as long as they produce beneficial results and they should never be subject to the caprice of politics. At present the insecurity of tenure is notorious, like the treaty of Alcibiades, famous because it is so infamous.

"The care of the public health should be the first duty of the statesman," is an oft-repeated aphorism, attributed to Benjamin Disraeli. Other masters of statecraft on both sides of the Atlantic have unburdened themselves of similar lofty declarations. From the days of Empedocles, who is said to have been the first sanitarian, to the present time, the customary manner in which statesmen have cared for the public health seems to have been to hinder as much as possible the sanitarian in his humanitarian endeavors. The biography of Gorgas is an account of a life-long struggle against petty and less petty annoyances placed in his path by pin-headed politicians, who had no conception of the immense value of his efforts, nor appreciation for his self-sacrificing devotion to a cause which played no insignificant part in the construction of the Panama Canal. Roosevelt had sense enough to back him up when Shonts tried to shunt Gorgas into obscurity and put an osteopath in his place, but later Goethals apparently never did cooperate effectively or credit sanitation with making possible his own remarkable engineering achievements.

The manner in which various and sundry so-called statesmen have "cared" for the public health is illustrated by a number of illuminating incidents, all actual occurrences within the last few years. When one of the recent mayors of Boston was running for office some few years ago he pledged himself if elected to remove the health commissioner as his first official act. This in spite of the fact that this health commissioner was a well-trained, capable administrator, who had been honored by his profession by having been elected to the presidency of the American Public Health Association, the professional society of sanitarians of North America. The candidate was elected and this health officer resigned promptly, or he would have been ousted just as promptly. Of course, his honor could argue that he

would accomplish more by having a subordinate who was persona grata to him, and it is true that this mayor has subsequently shown a decent interest in public health, but the general principle is wrong, nevertheless. As a contrast may be cited the example of Savannah, which some time ago asked the United States Public Health Service to conduct a competitive examination for a health officer, to be chosen entirely on merit. In the announcement of this examination it was stated "the position is guaranteed free from political interference."

Sometimes the health official who finds it expedient to change jobs when the administration shifts is better off in the long run. Recently the health officer of Kansas, who had effectively administered his department for nearly a score of years, was replaced when a new governor was elected. It so happened in this case that his successor was a competent sanitarian, though that does not alter the evil principle. The ousted official was promptly deluged with offers from other sources where his ability was appreciated and he is now the executive of a national voluntary health agency, of which Mr. Hoover is president, at a much larger salary than he probably ever would have received from his native state. On the other hand, it is not always a simple matter for a professional man, like a sanitarian, to step immediately into a new position after he has been relieved of his emoluments in another.

Numerous other regrettable incidents where politics has played havoc with the public health could be cited for all parts of the country. In Richmond, Virginia, a health official who had built up one of the best health departments in the country over the course of twenty years went out a few months ago because, as a caustic editorial in the *American Journal of Public Health* put it, "the voters preferred one mayor to another." In Philadelphia a competent director of sanitation was supplanted by a real estate man. These unfortunate incidents are luckily balanced now and then by more pleasant ones. The late Dr. Herman M. Biggs, for many years health commissioner of New York, was appointed by a governor of one political faith and kept in office by other governors of various political affiliations because he was acknowledged to be the best qualified man for the place. At the time of his death the deputy health commissioner was properly promoted to his place by the present broad-minded executive of the Empire State and it is fairly certain that politics had no influence in the matter.

North Carolina is a Democratic state, but it has at least one district which frequently goes Republican. On one of its lapses from this desirable or undesirable condition, depending upon one's point of view, it was proposed to replace the efficient county health officer with the only physician who had voted the winning Democratic ticket and who, incidentally, had no public health experience. The incumbent was apparently a Republican. The stage was all set for this inspiring spectacle when the Democratic state health officer, one of the best in the country, appeared on the scene. His pronouncement was something like this:

"Gentlemen, you can replace this capable health officer if you like, but I warn you that you must also replace his record. If you do not do so, the State Department of Health will hold you accountable." That put a different aspect on the matter, especially when the proposed candidate, to whom the situation had also been explained, voluntarily came forward and insisted that the health officer be retained. He had previously had the erroneous idea that the office was merely a political plum. It should be, of course, anything but that, but too often it is only that. When such

is the case, is there any wonder that some public health administration is full of waste motion and ineffective operation?

Since the record of an official is the criterion of his effectiveness and the one item which is occasionally irreplaceable, an attempt is now being made to evolve a system of appraisal for health departments. A rating standard has been worked out by the American Public Health Association, with the cooperation of other voluntary agencies, such as the American Child Health Association, and is now in actual use. This appraisal form was considered by a group of municipal health officials themselves, who conferred about it in a strenuous way for nearly a week last winter. Thus, this scoring system represents the consensus of professional opinion and when the public health activities of a community are determined by it, a scientific measuring stick has been applied. After this appraisal form has been in actual use for a year or so, it will be revised in the light of experience and will be then issued in a practically permanent form. The employment of such standards in evaluating the public health accomplishments of an official will undoubtedly be of much value in coping with the usually pernicious influence of politics in public health.

Another solution in the taking out of politics from public health is to put statesmanship into the science. Statesmanship is merely politics in an ethical form. The average scientific man is too often prone to be an amateur in political science. That is one reason why practicing physicians frequently do not make good health officers. A health official who knows how to deal with all kinds of people, especially other officials, can achieve scientific progress, provided, of course, he has some conception of the latter. This has been well demonstrated in cities like Bridgeport, Connecticut; Memphis, Tennessee; Detroit, Michigan; and the Oranges in New Jersey, where well-trained health officers with the right kind of a personality have managed to get along smoothly most of the time. It used to be the boast of the next before the last health commissioner of Chicago, before he succumbed to a reform administration, that he was the biggest political asset that Mayor Thompson had. He was, and not too bad as a health official, either. The voters of New York recognized the political acumen of the health commissioner of their largest city by sending him to the United States Senate. The keynote of the whole situation, then, is one of men. That means also that it is one of personality. Public health in the United States had made remarkable progress, but it can and will accomplish even greater and more alluring results when there is a copious supply of well-trained sanitarians, recognized as scientific individuals practising a dignified profession in a reasonable way, enhancing the national vitality and happiness of the citizens. When such men are available they must be provided with a decent compensation for their illustrious (let it be hoped) efforts and a tenure of office based entirely on merit. The time to divorce politics from public health, however, is now.

EXCURSIONS IN EXPERIMENTAL PSYCHOLOGY

By Professor RAYMOND DODGE

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EVERY experimental scientist is a kind of explorer or prospector. He spends his energy pushing his way here and there into the darkness of the unknown, blazing trails which may or may not lead to scientific treasure. Unlike the geographical explorer, he is relatively free from mortal danger, though not entirely free from perils that give a tang of adventure to his work. He may get lost in the chaos of details and never emerge. I have known such lost souls. He may spend his time in fruitless quest, following trails that lead nowhere, at the peril of a wasted life. He is not altogether free from the peril of combat. He may find himself in conflict with his colleagues or with the native inhabitants of the dark continent of ignorance, who voluntarily choose darkness rather than light and prefer prejudice to information. Not all of them live in Tennessee.

Many of the joys of the explorer are within his reach. The struggle for truth is never tame, and the joy of pitting one's intelligence against the unknown and trying to do impossible things is only less than the joy of occasional discovery. None of these satisfactions is ever quite so good second hand. The classic rhyme about the purple cow, "I'd rather see than be one," is reversed in the case of the scientific explorer, "I'd rather be than see one." But there is some joy in hailing fellow prospectors in the desert or mountains, the classroom or symposium, and swapping experiences.

Two questions are naturally asked when prospectors meet. The first is "What are you prospecting for?" And the second is "What have you found?" Now, according to human nature, prospectors who are looking for the same thing are more or less suspicious of each other. They tend to regard each other as rivals or competitors. On the other hand, prospectors who are looking for different things are apt to be a trifle contemptuous of each other. The trout fisherman doesn't like to see another fishing the same stream. If he is ahead of him, he may catch the fish and spoil the fun. If he is behind him, he may catch fish and make his predecessor look ridiculous. Both fates are unpleasant. Furthermore, trout fishermen commonly have a sublime contempt for the stranger who is fishing for bullheads or hunting butterflies or haying in the hot sun or even prospecting for gold. These aren't his ideas of real sport. So it happens that we are apt to be either a bit suspicious or a bit intolerant of our fellow travelers. But true sportsmanship curbs both the suspicion of rivals and the contempt for other interests.

Scientific exploration aims, not at amusement or profit, but at valid descriptive equations. Now there are two main types of description—the particularizing and the conditional.

PARTICULARIZING DESCRIPTION

To say this man is John is an entirely arbitrary but useful identification of an object of thought, but it is empty of content. To say that John has certain peculiarities of gait, countenance, manner of thinking, inheritance and educational background gives us real information about him. If the particularizing is

complete, it may be expressed in a scientifically adequate descriptive equation. That is to say, it is reversible. The man with all these peculiarities is John.

The most common fault of particularizing description is its incompleteness. Some prominent feature of the situation is apt to *dominate* attention to the exclusion of the less conspicuous factors giving rise to a kind of presocratic simplification of the facts, the illusion of the "nothing but." You remember how the first great Greek philosophers decided in succession that the universe was fundamentally nothing but water or air or little atoms of various shapes or eternal flux. The situation was not essentially different from that of the blind men who went "for to see the elephant" and who confidently decided, each from his own point of contact with trunk, leg, ear or side, that the elephant was nothing but a rope, a tree, a fan or a wall.

There have been many presocratic simplifications in the history of scientific and pseudo-scientific description. Not so long ago the universe was commonly held to be nothing but matter in motion. Matter recently seems to be disappearing, like the Cheshire cat, till nothing but the motion remains. The latest fad of the pseudo-scientific is the dogma that man is nothing but a kind of ape and the universe is nothing but a group of electrons.

Psychology has passed through similar periods of simplification. Mental phenomena have variously been held to be nothing but sensations and their complexes, or reflex arcs, behavior patterns or configurations. The latest fad in uncritical simplification seems to be the sex urge or the libido.

Obviously such crude judgments fall far short of the ideal of scientific description.

Dynamic Description

In a sense no mere particularization can ever be adequate description. An organic whole is never the mere chaotic sum of its parts. Somehow in the living organism those parts are integrated. And in the scientific description of the organism the principles of its integration are just as important, perhaps more important, than any attempt to enumerate its parts. Complete description can not ignore either the parts or the dynamics of their integration. The first we called particularizing; the second we may call dynamic description.

The chief traditional faults of the second type of description are, on the one hand, picking out some prominent antecedent and calling it *The Cause* of a phenomenon; and, on the other hand, assuming some mythical entity like faculty, instinct, general intelligence or personality as the sum total of all conditions. The first fault is amateurish, another case of crude simplification. Without adequate description the second has the futility of an empty name. While we can describe only one thing at a time, science demands just as rigid criteria of completeness in dynamic as in particularizing description.

No one can say that either of these two kinds of description is more important for science than the other; but, speaking for myself, things and events seem most interesting and most significant when they can be made to serve as indicators of their more remote and hidden conditions.

Regarded as indicators, almost infinitesimal and apparently trivial facts may become of vast scientific importance. The slip of a mountain measuring only a few inches tells the geologist of subsurface stresses and strains that may mean future earthquakes. The microscopic shift of spectral lines tells the astronomer the constitution, speed and age of distant suns. The microscopic measurement of diffraction rings tells him their distances. The business of modern astronomy is not merely to name the stars or count them or describe their ap-

pearance, but to arrange for painstaking and accurate measurements that shall indicate the underlying dynamics of the universe.

Neither particularizing nor dynamic description is ever final. Particulars can always be regarded as smaller wholes which might be further particularized if we had better techniques. Conditions can always be regarded as the consequence of more remote antecedent or underlying conditions. Each step in the particularizing or the dynamic study of phenomena always leads to further possibilities in the development of science and frequently to new fields of practical exploitation. I find that a study of the conditions is not only the more fascinating, but I believe it is likely to be the more fruitful in the conduct of life.

All my scientific exploring has been directed towards the most complete possible recording of significant behavior, not for itself alone, but for the sake of finding out what makes the thing work.

Eye Movements as Indicators

My first scientific exploring expedition into the dark continents of psychology was in the general field of language, especially in the psychology of reading. There is no time at present to describe in detail the things we found and the things they indicated. In collaboration with my great master and friend, the late Professor Benno Erdmann, the Psychologie des Lesens gave scientific importance to the accurate description of eye movements as opposed to the then current assumptions. Simple observation of the eye movements first indicated what have now come to be regarded as some of the fundamental characteristics of the reading process, especially the apprehension of word forms and the size of the reading field at the reading pauses. More accurate photographic records showed the significance of prefixational vision, individual differences in reading habits, the maturity of reading development and familiarity with text and text parts. They proved to be useful indicators in neural disease, especially in the catatonic form of dementia praecox. They are the most reliable signs of alcoholic intoxication. They served further in the analysis of the fatigue process, in the study of habituation to rotation, and have recently furnished the first recorded picture of neural rivalry and competition. This last deserves more than mere passing description.

If a person is rotated clockwise in a revolving chair, the eyes show a reflex compensatory counter-clockwise drift, with jerky returns to positions of less strain. The latency of this reflex compensatory drift, that is, the time interval between bodily rotation and the beginning of reflex eye-movement, is of the order of 60σ. Without vision the accuracy of compensation is seldom very high. The eyes will start quickly to move in the right direction, but adequate compensation requires the elaboration of data that the semi-circular canal reflex lacks. There results a kind of stratification of the eye behavior. Beginning as a reflex the overt act imperceptibly passes under control of higher centers. I sought to render this transition explicit by rotating the environment in the wrong direction. It was an intriguing question as to which would dominate, the fundamental reflex or the less stable pursuit reaction of the eyes. The records show that reflex compensation always comes first and passes slowly and with more or less hesitation into an adequate adjustment to the moving environment. Immediately when the visual perceptual data are shut off, the fundamental reflex snaps back into dominance at the same stage of adaptation that it would have had if it had not been interrupted. When controlling vision of the unusually moving environment returns, the higher arcs regain dominance slowly, gradually and often with a moment of hesitation. If the rotation is rapid enough to make

clear vision of the environment difficult and to correspondingly exaggerate the reflex stimuli, the period of hesitation lengthens and develops into a protracted episode of utter confusion and mal-adaptation which is characteristic of mental abnormality. I conjecture that this experimental procedure would yield important indicators of sub-normal cortical action. It should provide data for the early diagnosis of the dementias. However that may be, it is probably most useful just now as a paradigm of the interaction between instinctive action and rational control, the first experimentally recorded picture of the conflict and rivalry of cortical and sub-cortical centers for control of a final common path.

Integrative Consequences of the Refractory Phase

A scientific exploration which disclosed still more fundamental processes was a study of the results of repeated or continuous stimulation. It has gone somewhat slowly, extending over several years, and is not yet ended. The most intriguing and significant feature that I have to report is the integrative importance of that complex of metabolic processes which may for convenience be grouped under the concept of the refractory phase. The imbecilic knee-jerk will serve as a base of departure.

If one gives a sharp blow on the patellar tendon just below the knee cap, there results a contraction of the extensor muscle of the thigh, which constitutes what is known as the knee-jerk, or the patellar reflex. If that is measured, not by the movement of the leg, but by muscle thickening, the recorded curve shows first a little excursion at the moment when the blow is struck; then, a sharp rise at the moment of reflex thickening of the quadriceps muscle, and finally a gradual irregular decline, as the muscle slowly resumes its normal tonus or thickness. The time relations are significant. Between the moment when the blow is struck and the reflex thickening, there is a latent period of about .04″. The reflex thickening lasts about .04″ more, and the gradual decrease in thickening to normal lasts about half a second. If, after the muscle thickening is complete, the patellar tendon is struck a second blow, one gets a similar mechanical vibration from the blow, but no reflex thickening. The second blow came at a period of relative inexcitability of the reflex arc, and the lack of reflex response is an indicator of what is commonly called a refractory phase. If the second blow occurs somewhat later in the course of muscle relaxation, the response is proportionately greater. If it comes just after the relaxation of the muscle is complete and the curve has returned to its base line, the second reflex thickening is greater than the first. This is the phenomenon of the rebound. It indicates a period of increased excitability of the reflex arc which follows its recovery from a previous refractory phase.

Refractory phase or a period of relative inexcitability of irritable tissue after its reaction was originally discovered in the heart muscle by Kronecker and Stirling and was graphically recorded for the first time through the genius of Marey. Since then the refractory phase has been found in irritable tissue wherever it has been sought with adequate techniques. In nerve fiber it is extraordinarily short, of the order of .002″ to .007″. It has been found in isolated muscle, in the reflex closing of the lid, where it has a duration of two to three seconds, and in the swallowing reflex. In short, it seems to be a characteristic of all living substance.

The exact place of origin of reflex refractory phase is an interesting physiological problem. Obviously, a refractory phase of two to three seconds can not be a function of the axone, since that has an absolute refractory phase of only .002″. There is similar evidence that it does not reside in the muscle. For the same

reason it is obvious that it does not reside in the final common path. Moreover, voluntary contraction may precede or follow reflex contraction without decrement. There is a consequent general presumption that it is a phenomenon of the synapses between the neurones, and that in some way, still unknown, the irritability of some link in the chain in neural happenings is depressed by a previous excitation, while later the irritability is increased in the rebound after the original equilibrium has been restored.

I have a suspicion that similar synaptic changes are very widespread phenomena, producing corresponding changes in our experience and behavior. It seems probable that something similar to a refractory phase follows every cortical act, limiting its repetition or at least tending for awhile to make repetition more difficult.

If the Verworn-Lucas theory is true, refractory phase is the fundamental condition of inhibition. The phenomenon may be illustrated by the action of the knee-jerk to a rapid series of stimuli. If the stimuli succeed each other within the refractory phase from three to ten per second, there is a corresponding decreased reflex response which becomes complete inhibition at the higher frequencies. That is to say, at a frequency of ten stimuli a second, the first blow only evokes a normal reflex. The second and subsequent reactions are much reduced or may be entirely lacking. In the latter case a curve of the muscle thickening shows only the mechanical vibration in response to the blow without any reflex reaction.

Unfortunately this schema does not immediately apply to inhibitions in mental life, as the following illustration will show. If one tries to recall an unfamiliar name, the emergence of a wrong name may for a time delay the recall of the right one. Such a case offers no analogy to the inhibition of the knee-jerk through the development of a refractory phase from an antecedent reflex, since in this case the right name is not available even for an instant. Some mechanism must be at work which prevents the necessary neural action without first introducing it to develop a refractory phase. The question led to an experiment crucis. Would it be possible to develop refractory phase by stimuli which were too weak to evoke an overt response?

Experimental trial gave a positive answer to this question, both in the knee-jerk and in the lid reflex. By properly graduating the stimuli, beginning with faint stimula and ending with a stimulus that under ordinary circumstances always evoked an overt reflex act, the response was regularly decreased and occasionally failed to appear at all. This experiment not only seems to confirm the Verworn-Lucas theory of inhibition, but to explain many cases of what is commonly called adaptation in everyday behavior and experience. For example, one may get used to stimuli that would otherwise be very serious in their reaction consequences, provided the stimuli are increased to maximal proportions by gradual steps. Styles that now seem quite normal and natural would not have been tolerated if they had come suddenly. The Navy develops its gun pointers for the big guns by gradually increasing the caliber of the guns that the enlisted man is permitted to fire. Whenever this precaution is not taken, gun shyness is sure to develop from the noise and recoil. Orchestral volume that would be annoying to the listener if it came suddenly may reach the same intensity in a crescendo by gradual increments and be thoroughly enjoyed. One may indeed become almost intoxicated by noises whose volume would be intolerable except by slow increment. I vividly remember an Easter morning when I approached the ringing chimes of the Cathedral at Innsbruck. As I came nearer and nearer, it seemed as though

the noise couldn't be intense enough. I demanded more and more, and when I was finally standing under the bell tower I had an almost irresistible impulse to climb the tower to get more of that noise. You may have felt the same during a Tschaikowsky crescendo. The phenomenon has many analogies in experience and conduct. A climax is usually reached at last when the stimuli reverse the feeling tone.

One might ask what would happen to a reflex pattern which was made up of several partial reactions of different refractory phases. Suppose, for example, analysis of a given reflex pattern showed that it was composed of three acts, A, B, C. Suppose also that the refractory phases of B and C were, respectively, two and three times that of A. It seems probable that, if adequate stimuli are repeated sufficiently frequently, B and C will be temporarily eliminated from the overt response, leaving A alone with its relatively short refractory phase. As a matter of fact this supposition proved to be true in at least one instance where the records are entirely adequate, as the following experiment will show.

I was watching a guinea pig one day with my young friend, Mr. Louttit, when we observed an interesting and suggestive modification of its behavior. When I clapped my hand once only, the pig jumped or started in a manner which we found difficult to describe from simple observation. It also jerked its ears downward and backward. If I kept on clapping, it ceased to jump and merely jerked its ears. If the clapping continued long, fast, and loud enough, the animal ceased to jerk its ears, laid them back in tetanic contraction and started to run. Superficially it looked like a phenomenon which would be classified in the traditional psychology of learning. He might be said to have learned that the clapping of the hands was harmless and that, consequently, he ceased to jump or start and developed a complex protective response. This would be a reasonable explanation of his covering the external meatus with the ears and running away from the noise.

But we were suspicious of this interpretation, since the whole performance could be repeated after a short interval and since the animal ran in any direction in which he happened to be pointed, including the direction of the noise. The phenomenon seemed worth investigating, so we invented a device to record it. You may be interested in the details of its construction.

In front of our silent photographic recorder we suspended a light basket carriage on two point bearings and a spring. When the animal was in position in the basket, this balanced carriage brought a thin wooden offset into the beam of recording light, casting a shadow across a slit in a screen, which otherwise covered a sheet of sensitive photographic paper. The shadow remained stationary when the animal was still, but moved up and down the slit when the animal moved. Such a recording device is practically frictionless, has very low latency and may be made to have great sensitivity. Our recorder showed initial trembling of the guinea pig. One could count his respirations and occasionally we observed what we took to be his pulse, though this latter was not confirmed. A noise-producing instrument, also situated in front of the photographic recorder, was fitted with a similar offset, whose shadow fell across the upper part of the same slit. The recording light and the shadows of the offsets falling across the narrow vertical slit or rather a lens system, which amounted to a slit, fell upon the sensitive paper as it was moved evenly behind the opening and developed into horizontal shadow records of the sequence of events. The interruption of the recording beam of light by a toothed wheel, driven by a tuning fork, furnished time ordinates .01″ apart.

The resulting records entirely confirmed our suspicions. The latency of the start reflex varied between .02″ and .03″, while its refractory phase was absolute within the limits of our records, which were of the order of .5″. A thin recording lever laid across the ear gave comparable records of its reflex movements. They showed an amazingly low latency of the general order of .015″ to .018″, with a refractory phase that was not longer than .65″. These records proved that we were not dealing with a true learning process at all, but with a modification of the reflex pattern at a very low level of integration, determined primarily by differences in the refractory phases of the several components. The final step is still in the hypothetical stage. We do not know precisely what made the animal run when the stimuli were of higher frequency and intensity. It looks like a summation process by which otherwise inadequate stimuli reach levels of response which are usually inaccessible to single strokes. It seems to me that the phenomenon is not only interesting in itself, but indicates a principle of very wide application to the phenomena of conduct and experience. It is at once an explanatory principle for understanding life as we find it and a primitive condition of the integration of human behavior.

Just what I mean may be illustrated by another experiment. In connection with a long and very tedious study of the effects of repetition of stimuli at different levels of the nervous system, which was undertaken with the help of a subsidy from the Ernest Kempton Adams Research Fellowship of Columbia University, I found that a refractory phase occurred in systems of reaction where it might be least expected. I discovered it in the ordinary course of those anticipatory reactions which we commonly call learning by insight. Let me repeat a simplified experiment with your cooperation. I shall spell a series of words backwards. Please speak them out loud as soon as you know what they are. N-i, s-e-y, d-a-r-b, e-g-a-p. You more or less readily reintegrate the succession of letters and respond with the words *in, yes, brad, page.* If I were now to repeat the experiments and begin n-i, you would no longer have to wait for the completion of the adequate stimuli. You would anticipate them and might react by saying the entire series of words before I had spelled the first one.

If the words were then spelled through backwards once again, you would probably sit back in a complacent attitude waiting for something new. Your task is done. For some reason or other the reaction systems have become relatively inexcitable after the first response.

There is something strange about this relative inexcitability of the paths of recent responses. Since recency is commonly regarded as one of the most important conditions of recall, the reaction systems on the basis of traditional psychophysiology might be supposed to be in a strategic condition for immediate repetition. Why are our last acts not commonly repeated indefinitely after the initial operation? A relative refractoriness of neural systems would have double teleological value. It would be at once a protection against monotony of behavior and would open the way for new and more adequate adaptive responses. If recency of reaction resulted only in the increased irritability of a neural system, the first chance reaction would tend to be repeated interminably. It is a kindly fate that each neural event contains in itself the conditions of its suppression as well as those of its repetition. The consequence of this interplay of tendencies is eternal change, even in the relatively stable patterns of behavior which we call habit and custom.

Occasionally emotional reinforcement develops behavior patterns of extraordinarily low refractoriness. There results a consequent stereotypy in thought or

behavior which may on occasion assume pathological features and result in exhaustion. Occasional suppression of competing systems permits another kind of behavior pattern of extraordinary simplicity. The consequent sterotypy is of a different order from that which is produced by low refractoriness. Its most characteristic feature is stupidity. Relative fixity of behavior for lack of competition is a phenomenon of depressed intellectual activity or senility, whether it is found in an individual or a race.

How long does relative refractoriness last after initial reaction? There is probably no universal answer to this question. Each event and apparently each factor of an event has its own individual peculiarities of latency and refractoriness. Ordinarily in oral or written discourse one does not repeat an important word within the sentence, a phrase in the paragraph, or any paragraph at all. Still less do we care to hear or read such repetitions. We seldom read a novel twice. A repeated joke or story is a bore except to the narrator. With respect to many of the phenomena of repetition, however, there is a common difference between motor and perceptor refractoriness. I had a much loved friend whose one weakness used to be the persistent repetition of witticisms. He regularly laughed at them. They apparently seemed mighty good to him. His audience often laughed too, but chiefly through the reinforcement of loyalty or affection. One's wife and one's students not infrequently become similarly conditioned.

Analogous differences between motor and perceptor refractoriness appear in connection with a great variety of events, from the repetition of favorite words and phrases, the blowing of penny whistles and the explosion of firecrackers to the reading of scientific lectures and the representations of art objects. There seems to be a peculiarity of great art, however, that decreases perceptual refractoriness as well as motor.

It may be objected by some of you that we have no direct evidence for decrements in central irritability of any such duration as I have suggested. I maintain on the contrary that we do not lack evidence for such persistent changes of irritability in cortical reaction arcs. There are many phenomena in the psychology of learning that indicate long enduring changes in the readiness of systems to react. This involves some change in cortical tissue which is lost only slowly or not at all. Flashes of insight can at present be understood neurologically only as modifications of the synapses, which are practically permanent. Since all memory involves negative changes as well as positive, the elimination of competing associations can be thought of neurologically only as more or less permanent depressions in the irritability of the respective neural systems. It would be idle to speculate on the precise mechanism of such neural changes. It is physiologically unknown. Hypotheses of retraction of synaptic endings, of chemical blocking substances, and of change in the resistance of semipermeable membranes have all found some measure of acceptance. None is established or has achieved any high degree of probability. It is perhaps sufficient for our present purpose to realize that such increases and decreases of irritability are facts as well as problems.

Somewhere, somehow, the recovery of irritability is delayed in neural systems just as surely as it is in nerve or muscle fibers. There is some evidence which points to the localization of these modifications in junctional tissue or at the synapse. Refractoriness at any point in a system would tend to depress or even prevent the reaction of that particular system to a renewed stimulus. This does not mean that any factors in the system are fully paralyzed. They may react to

different or to stronger stimuli. They may react to the same stimulus in a different constellation. Common experiences as well as our experimental facts fit best the relative refractory phase schema.

I have tried to outline some of the evidence for the existence of a primary underlying factor in the variability of human response which is at once a protection against stereotypy and a condition of resystematization. If it were not for this underlying tendency all our lives might be spent in circles of narrow circumference and in the repetition of trivialities.

Neural patterns in the cord and brainstem quickly reestablish their original sensitivity, and the consequent behavior patterns are quite permanent and characteristic of the indivdual. Even these, as we have seen, may change from the action of relative refractoriness. In labile or fluid neural systematizations like those of the cortex relatively slight decrements in the irritability of any link in the neural chain may produce profound modification of the behavior pattern or even apparent reversal of the mode of reaction.

If I may be permitted to point out in conclusion the main land-marks in our scientific excursion, I would emphasize the strategic importance of those phenomena whose accurate description under experimental conditions reveals something of the underlying processes, as, for instance, when outcrops of overt behavior may be arranged to serve as indicators of the underlying neural action.

We have shown how such overt acts as eye movements, knee-jerks, lid reactions and the like may reveal the momentary status of relatively stable neural systems and the interplay of various segmental levels of neural integration. We have shown further how a study of the sequence of such overt responses may be made to reveal far-reaching principles of integration like the refractory phase and the rebound. These are such fundamental conditions of normal life that psychology would be forced to invent them as hypotheses for the explanation of human experience and behavior even if experimentation had failed to disclose them.

THE BIRTH OF MODERN SCIENCE

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I

THE word science is capable of interpretation in so many different ways that it is desirable to define exactly what is meant by the term modern science. To many people the phrase suggests a Marconi, an Edison and the host of mechanical devices with which the application of scientific principles has deluged the world. Now while the writer has no intention of belittling the importance of applied science, in this historical sketch attention is directed to the work, not of the inventor but rather to that of the investigator who patiently and persistently seeks to learn something of the secrets of nature. Our modern scientist is the man who is more interested in a knowledge of the ultimate structure of gold than in its possession; who seeks not to build aeroplanes but to understand the laws of flight; who studies the starry heavens, not to cast horoscopes, but to learn something of the universe of which he is a part; who looks at the lilies of the field and wonders why they grow.

It is important to realize that a man of this type is no idle dreamer. He does not sit and gaze at the heavens seeking to evolve in his own mind the laws of the universe. On the contrary, he is a very practical person who tries to unlock the closed doors of nature by a well-defined method. In the first place he makes observations; he collects all the facts he can about the problem he is investigating. Not content with observations, he experiments to find additional facts. When a fair amount of accurate knowledge has been collected in this way, he tries to correlate the facts in what appears to be a reasonable explanation. In other words, he formulates a theory. Having formulated his theory, he proceeds to test it. If this theory is true, he says, then such and such should be the case. He, therefore, makes further experiments to see if his predictions are true. If they are not, that is, if the new facts thus brought to light do not fit in with his theory, it must either be revised or cast overboard altogether. His ultimate aim is truth. No matter how much he has prided himself on the beauty or on the correctness of his theory, a single fact which it fails to explain is sufficient ground for either altering it or casting it aside in favor of a new one.

Let me illustrate by a concrete example. Towards the end of the seventeenth century there were two outstanding theories concerning the nature of light. According to the first, a stream of extremely small particles is shot off from a luminous body. These corpuscles, as they were called, travel at a high speed through a vacuum and all transparent bodies, strike our eyes and cause the sensation of light. Supporters of the second theory stated that disturbances in the luminous body were the cause of trains of waves which were sent out in all directions. These waves, travelling through an invisible ether filling all space, impinge on our eyes and in this way the sensation of light results. *Now both these theories were attempts to explain existing facts.* It was known, for example, that light travels in straight lines; that a beam of light may be regularly reflected, and suffers refraction when passing from one medium into another. Neither of the theories, however, provided a completely satisfactory explanation of these and other facts.

Which was nearer the truth? This could not be decided until additional experimental facts had been obtained, and it was not until about the beginning of the nineteenth century that overwhelming evidence was given in favor of the wave theory. About the year 1800 Thomas Young showed experimentally that light added to light could give rise to darkness. Here was a fact which the corpuscular theory could not explain. It had either to be altered or overthrown. Later in the century it was shown, again by direct experiment, that light travels *more slowly* in water than in air. Now according to the corpuscular theory, the fact of refraction was explained on the supposition that light travels *more quickly* in a medium like water than in air. Here, then, was another direct contradiction to an experimental fact. The corpuscular theory, therefore, was given a knockout blow and at the beginning of the twentieth century the wave theory was almost universally accepted. It is still, however, only a theory. The last decade or two has seen many new discoveries in the world of physical science and some of these can not be satisfactorily explained by the wave theory, at least in its present form. The end is not yet and the search for truth goes on.

To sum up, modern science is born of a spirit of wonder and inquiry about the whole world of natural phenomena. Its keynote is found in the word, experiment; "Experiment and see" is the scientist's answer to innumerable questions. Its method is a combination of induction and deduction; theories are formed by inductive reasoning; they are tested by deduction. Scientists themselves must ever keep an open mind and at least aim to live up to the somewhat flattering tribute of Mr. H. G. Wells, who speaks of them as men who "think and work with an intensity, a breadth, boldness, patience, thoroughness and faithfulness—excepting only a few artists—which puts their work out of all comparison with any other human activity . . ."

How long has science been one of man's normal activities? When did modern science have its birth? These questions, like all others dealing with the beginnings of things, are not easy to answer. The accomplishments of the ancient Chaldean civilization are sufficient evidence that even in prehistoric days man had much knowledge of the physical world about him. Whether the men of those days had any real scientific outlook, even in the slightest degree, it is not possible to say. There is no doubt, however, that in the mental outlook of the Greek philosophers of the fifth and sixth centuries B. C., we find much that is in common with that of the twentieth century scientist. Thales, with his conception of water as the ultimate primary substance; Anaximenes, with his substitution of air for water and his theory of rarefactions and condensations; Herakleitos, with his idea of fire as the ultimate reality; Empedocles, with his four elements, earth, air, fire and water, were surely men seeking to explain natural phenomena. To Leukippos and Democritus atoms may have been more of an ultimate reality than they are to the twentieth century physicist, but these were men who undoubtedly were concerned about the structure of matter. Nor was experiment altogether absent in these early days. Empedocles, for example, is said to have proved the fallacy of the doctrine that space is "empty" by the use of a water clock. Water would not flow in, unless air went out. Air, therefore, he argued, is not empty space. Even before Empedocles, Pythagoras or the Pythagorean school was familiar with certain laws regarding musical intervals, laws which could scarcely be obtained without a certain amount of direct experimenting.

As we come nearer to the Christian era we are on more solid historical ground. The mass of extant literature

ascribed to the great Aristotle is ample evidence of the existence of the scientific spirit during the fourth century before Christ. The very names of many of the Aristotelian treatises—concerning physics, concerning the history of animals, concerning sound, concerning colors, concerning plants, concerning mechanics and so on—these very names show the interest of the philosophers of his time in scientific matters. In Aristotle's works we find a veritable mine of information on scientific subjects which many centuries later was to have such a tremendous effect on man's intellectual development. Aristotle, moreover, not only collected information but apparently also recognized the desirability of exact observation and of the necessity of a hypothesis "fitting the facts." "The phenomena are not yet sufficiently investigated. When they shall be, then one must trust more to observation than to speculation and *to the latter no further than it agrees with the phenomena.*" This is sound scientific doctrine, but Aristotle did not always practice what he preached. In one of his works he says: "That body is heavier than another, which in an equal bulk moves downward quicker." Bodies fall faster, the heavier they are. Now even a college freshman knows that this is not true and it is a very simple matter to prove the error experimentally. Apparently Aristotle and his school did not always use the experimental test.

Turning to Archimedes we find essentially a modern physicist. His discovery of the principle of the lever is a matter of common knowledge because of the saying attributed to him, "Give me a fulcrum on which to rest and I will move the earth." Almost equally well known is his work on hydrostatics and the principle which still goes by his name that bodies immersed in a liquid lose in weight an amount equal to the weight of the liquid displaced.

Of the accomplishments of Archimedes in mathematics and in engineering details can not be given, but there is no question that there is ample justification for the statement of Leibnitz, "whoever goes to the bottom of the works of Archimedes will admire the moderns less."

From even the briefest survey of Greek science, one can not omit the names of two other men, Hipparchus and Ptolemy.

Hipparchus, an astronomer who lived in the second century B. C., both in his outlook and in his methods was essentially a modern. Not content with accepting as final either the work or the theories of his predecessors, he made new and more accurate observations by means of which he showed the incorrectness of existing theories concerning the motions of heavenly bodies. Moreover, like a true modern, he worked out a new theory of the motion of the sun and the moon which was satisfactory in that it fitted the actual facts to the accuracy with which he was able to make observations. When we add that he discovered the astronomical phenomenon known as the precession of the equinoxes and laid the foundations of trigonometry, we must admit that Hipparchus is entitled to be ranked with the pioneers of modern science.

For over 250 years after Hipparchus no outstanding advances were made in the field of astronomy. In the second century of the Christian era, however, we encounter the work of Ptolemy, another outstanding name in the history of science. Of his varied activities one or two details only can be given. In optics he investigated experimentally the phenomenon of refraction, thus providing us with what one writer has described as "the oldest extant example of a collection of experimental measures in any other subject than astronomy." His most important work, however, was in the field of astronomy. Few ancient

scientific works are of more importance than his Syntaxis or the Almagest, as it is more frequently called, a treatise in which he presents a complete account of the astronomical facts, theories and instruments of his day. Of the tremendous importance of this treatise in medieval and renaissance days mention will be made later.

There is much evidence, therefore, that the Greeks laid the foundations of modern science. It is true that in many there was a confused blending of philosophy and science, a tendency to speculate rather than to experiment; it is equally true that in others we find a combination of the true scientific temper with the use of the experimental method. But Greek science declined and for many centuries, at least as far as European civilization is concerned, it was almost completely eclipsed. In spite of the amazing accomplishments of the Romans, their work in pure science is of little account. Their genius lay in other directions, along lines which were not favorable to the further development of science. Possibly it is unfair to cite the case of the Roman soldier who killed Archimedes as typical of the attitude of the soldier's race to abstract science, but at least it is suggestive of the difference between the Greeks and the Romans.

With the acceptance of Christianity by the Roman world, conditions became less and less favorable for the development of science. It was perhaps not unnatural that the early Christians should view with disfavor the intellectual activities of a people whose morals were not always of the best and whose outlook in many matters was frequently paganistic. In any case we find a twofold attitude displayed towards scientific matters. There was first of all a kind of contempt for such questions, a feeling that matters concerning the soul's salvation were so urgent that after all such studies were of little moment. "What concern is it to me," says St. Augustine, "whether the heavens enclose the earth in the middle of the world or overhang it on either side?" Basil of Caesarea states "it a matter of no interest to us whether the earth is a sphere or a cylinder or a disk or concave in the middle like a fan." But interest in the world about us is a natural instinct, and of this there is ample evidence in the other attitude of the early church fathers towards science. In the scriptures can be found the solution of many scientific questions and disputes. Why go to pagan philosophers when we have the law and the prophets? By way of illustration, consider an argument advanced in the sixth century by Procopius of Gaza against the possible existence of men on the antipodes. Such a thing is out of the question, he argued, because it would mean that our Lord must have gone there and died a second time. In support of the same position St. Augustine argued that such men could not exist because "Scripture speaks of no such descendants of Adam."

Gradually, therefore, the church developed a sacred pseudoscientific system of the earth and of man's place in the universe. Utterly unscientific in its formulation, it was supported with the tremendous authority of the church of the middle ages, and, as we shall see later, became a stumbling block in the face of which real scientific progress was a very difficult matter.

The downfall of the decadent Roman empire before the invasion of uncultured barbarians was a second powerful factor in bringing about a condition of affairs totally unfavorable to scientific advance. Much of the ancient learning was lost and civilization sank to the low ebb implied in the name Dark Ages. Throughout this period knowledge and intellectual interests were in the hands of the clergy; political life was one of wars and readjustment, while, to quote Professor G. B. Adams, to many people "the dark terrors of the world of lost

souls, which they crudely but vividly pictured to their minds as horrible physical torments, pressed upon them with a reality almost as immediate as that of the world in which they were really living." In such an atmosphere the spirit of modern science did not exist.

II

Only a brief reference can be made to the conditions which gradually created an atmosphere favorable for the rebirth of the true scientific spirit. During the Dark Ages there was much activity along mathematical and astronomical lines among the Hindus and Mohammedans of the far east. While they seem to have made but few new contributions to science, Greek ideas were preserved as well as translations of Greek manuscripts. Now, as is well known, during the ninth and tenth centuries Mohammedanism spread into Europe and a remarkable Moorish civilization arose in Spain. Almost palatial in its splendor, strangely enough it was marked by an intense interest in learning, particularly on the scientific side. To quote Hume:

> Cordova then became the center of scientific investigation. Medicine and surgery especially were pursued with intense diligence and success, and veterinary surgery may be said to have crystallized into a science. Botany and pharmacy also had their famous professors, and astronomy was studied and taught as it had never been before; algebra and arithmetic were applied to practical uses, the mariner's compass was invented, and science as applied to the arts and manufactures made the products of Moslem Spain—the fine leather, the arms, the fabrics, and the metal work—esteemed throughout the world. . . .

Before this remarkable era in Spain had come to an end, a new ferment was at work in Europe. Contact with the east as a result of the Crusades and gradually developing commerce had enlarged the horizon of many men and stimulated their imaginations. New impulses began to stir, minds became more active. The more settled state of Europe permitted scholars to go afield in search of knowledge and of manuscripts, visits even from England to Spanish centers of learning being not unknown. Indeed, in the twelfth century there was such a revival of learning that, according to so eminent an historian as C. H. Haskins, we have to do with a true renaissance. While this movement centers largely in numerous translations of Greek manuscripts into Latin, it is by no means unrelated to the theme of this article. The translators of this period were interested not so much in the humanistic side of the classical writers as in their scientific and philosophic knowledge. And so we find Latin translations of the works of such men as Ptolemy, Euclid, Galen, Hippocrates and Aristotle. Aristotle's logic, it is true, had been known and indeed of great importance throughout the Dark Ages, but in the twelfth century his scientific works gradually made their appearance. Translations of Ptolemy's Almagest, with its thorough summary of Greek astronomy, came to light both from Arabic sources about 1175, and somewhat earlier, from Greek sources through Sicilian channels. In the twelfth and thirteenth centuries, therefore, scholars had at their disposal numerous Greek scientific works. What use did they make of them? Is there any evidence that the interrupted stream of scientific activity once more began to flow along Hellenistic channels?

To that question we may answer both "yes" and "no"; yes, because there is undoubtedly much evidence of the existence of the true experimental scientific method during this period; no, because influences opposed to the rebirth of the spirit of the Greeks in some respects increased rather than decreased. The positive evidence will be given by a glance at the work of two outstanding figures of the thirteenth century. In the Norman kingdom of Sicily, where Latin, Greek and Arabic influences came together, there ruled at this time a remarkable per-

sonality, King Frederick the Second. The head of a court which patronized learning, he himself had an active scientific mind. That he was also an experimentalist there is some evidence in certain tales which are related of him. Wishing, for example, to know the comparative effects of sleep and of exercise on digestion, he gave to each of two men a hearty dinner. After their repast, one was sent hunting, the other ordered to take a sleep. Later, the two were put to death and an analysis made to see whether rest or exercise were the better aid to digestion. Another story of a less scientific nature is to the effect that certain children were brought up in silence in order to find out "whether they would speak Hebrew, which was the first language, or Greek or Latin or Arabic or at least the language of their parents; but he labored in vain, for the children all died."

His real scientific work, however, lay in the field of natural history. A fondness for animals, combined probably with a love of show, led him to bring together a veritable menagerie of "elephants, dromedaries, camels, panthers, gerfalcons, lions, leopards, white falcons and bearded owls." But it was by no means for show alone that he used his animals. A treatise on falcony, "De arte venandi cum avibus," is ample evidence of an exact scientific study of the habits of such birds obtained by accurate observation on his own part, combined with a systematic investigation of the knowledge of others. Moreover, while familiar with and to some extent following the works of Aristotle on natural history, he did not hesitate to criticize the great master, even accusing him of at times relying too much on hearsay. That Frederick's interest in scientific matters was not limited to natural science, one illustration must suffice. Following a custom to which he seems to have been addicted, he at one time sent to the sultan of Egypt the following optical questions for solutions by Moslem scholars: (1) Why do objects partly covered with water appear bent? (2) Why does Canopus appear bigger when near the horizon, whereas the absence of moisture in the southern deserts precludes moisture as an explanation? (3) What is the cause of the illusion of spots before the eyes?

A much more important and almost equally dramatic figure is found in the person of Roger Bacon. Born in England at the beginning of the thirteenth century, he seems to have spent his early manhood studying at Oxford. At Paris he continued his studies, taking the dialectic training of his day and ultimately receiving the doctor's degree. Subsequent work at Oxford rendered him suspect to the members of the Franciscan order to which he had attached himself, and once more he returned to Paris, this time more or less under surveillance. A few years later the interest of a liberal-minded pope gave him an opportunity to write his famous works and so to hand down to posterity a detailed account of his accomplishments. A later treatise in which he in scathing terms denounced the evils of the church and society of his day proved too much for the superiors of his community, and a period of fifteen years in prison put an end to further writing. (When an old man he was released, but it was then too late for him to do any further work of importance.)

Now, what did this man do and why is he so outstanding a figure in the history of science? Note what he himself has to say:

> For now I have laboured from my youth in the sciences and languages, and for the furtherance of study, getting together much that is useful. I sought the friendship of all wise men among the Latins, and caused youth to be instructed in languages, and geometric figures, in numbers and tables and instruments, and many needful matters. I examined everything useful to the purpose, and I know how to proceed, and with what means, and what are the

impediments; but I cannot go on for lack of the funds which are needed. Through the twenty years in which I laboured, especially in the study of wisdom, careless of the crowd's opinion, I spent more than two thousand pounds in these pursuits on occult books and various experiments, and languages and instruments, and tables and other things.

Again:

The study of wisdom may always increase in this life, because nothing is perfect in human discoveries. Therefore, we later men ought to supplement the defects of the ancients, since we have entered into their labours through which, unless we are asses, we may be incited to improve upon them. It is most wretched always to be using what has been attained and never reach further for one's self. . . . In every act of life, or business, or study, these three vast arguments are used for the same conclusions: this was the way of our ancestors, this is the custom, this is the common view: therefore should be held.

Surely we have to do with a man who, like the modern scientist, is not willing to accept as final the conclusions of his predecessors, who refuses to accept the argument of mere tradition, who realizes that new knowledge may be obtained by observation and experiment.

Turning to his scientific writings, we find them treating of a vast range of subjects, into the details of which it is not possible to go. In any case, what the writer would like to emphasize is not so much his actual scientific accomplishments as his insistence on the necessity of the experimental method. To him the crowning test of the truth of all knowledge lay in "experimentia." Let him again speak for himself:

There are two modes of arriving at knowledge, to wit, argument and *experimentum*. Argument draws a conclusion and forces us to concede it, but does not make it certain or remove doubt, so that the mind may rest in the perception of truth, unless the mind find truth by way of experience.

Again:

But beyond these sciences is one more perfect than all, which all serve, and which in a wonderful way certifies them all: this is called the experimental science, which neglects arguments, since they do not make certain, however strong they may be, unless at the same time there is present the *experientia* of the conclusion. Experimental science teaches *experiri*, that is, to test by observation or experiment, the lofty conclusions of all sciences.

Finally:

When Aristotle speaks of knowledge of the cause as a higher kind of knowledge than that gained by experience, he is speaking of mere empiric knowledge of a fact; I am speaking of experimental knowledge. There are numerous beliefs commonly held in the absence of experiment, and wholly false, such as that adamant can be broken by goats' blood, that a vessel of hot water freezes more rapidly than one of cold and so on.

Now two examples do not establish a case, but they do serve to illustrate the point which might be amplified, that in the thirteenth century there were unmistakable signs of a rebirth in science. On the other hand, influences opposed to the spirit of a free and an experimental inquiry into natural phenomena were not lessened by the new knowledge. In Roger Bacon himself, we see an example of one such influence. In spite of all that has been said concerning his position as a scientist, in one respect he is no exception to the philosopher-theologians of his day. To him, as to them, theology was the queen of the sciences; all other branches were her handmaidens. It must be remembered that throughout the medieval ages learning was for the most part in the hands of the theologians. While many of these, particularly in the latter half of this period, were extremely able men, and some not without an interest in natural phenomena, the keynote of all their studies was theology; salvation, not science, was their primary concern. The result was often a strange mixture. Here is one example of a scientific question and its theological answer: "Why is the sun so red in the evening? Because he looketh down upon hell."

It is in scholasticism, however, that we find the strongest of all the influences opposed to the development of the scientific spirit. Scholasticism, strangely enough, was one of the results of the intellectual stimulus which came to Europe at this time. A wealth of new material, in the form of bad Latin translations, is brought to the attention of men whose wits had been sharpened by the prevalent training in logic and in dialectic, whose interests were predominately theological, whose minds were stimulated by the economic and political changes affecting the Europe of their day. It is not surprising, therefore, that such men, seizing on the new but often inaccurate material, endeavored to incorporate it in their theological system. With Aristotle as a theologian they had long been familiar; of Aristotle, the natural philosopher, they were at first somewhat afraid, and we read of the prohibition of some of his works at the University of Paris. Soon, however, the ban was removed, and it was not long until the able minds of the thirteenth century had gladly accepted a somewhat perverted Aristotle and had created what G. B. Adams has described as "a gigantic system of organized knowledge, in so far as there was knowledge, in which almost every conceivable idea had its place, and which exercised a most tyrannous sway over all mental activity, because it was so intimately bound up with an infallible system of theology which every mind was obliged to accept under peril of eternal penalties."

Now it need scarcely be added that the spirit of such a system, dominated as it was by the double authority of an infallible theology and a misrepresented Aristotle, was almost fatal to scientific progress. It is true that the early schoolmen included in their number some of the keenest intellects the world has known; it is equally true that their scholastic philosophy developed into the most futile speculations. For example, we read of questions such as these: "Could God make two hills without an intervening valley?" "Could God make a stick a yard long which had not two ends to it?" "What happens when a mouse eats the consecrated host?" Had later scholastics done nothing but "spin laborious webs of learning out of no great quantity of matter and infinite agitation of wit"—to quote Francis Bacon—we might pass by with nothing but a smile. But such was not the case. The syllogism, for example, was applied to scientific problems as well as to philosophical. A good illustration of its use is found in the following argument concerning the antipodes, used by a Spanish theologian in the fifteenth century. "The apostles were commanded to go into all the world and preach the gospel to every creature; they did not go to any such part of the world as the antipodes; they did not preach to any creatures there; ergo, no antipodes exist."

While the thirteenth century, therefore, undoubtedly gave evidence of the dawn of the twilight of a better day, full daylight was not to come until many storm clouds had passed. In the imprisonment of Roger Bacon for "certain suspected novelties"—as his accusers put it—we see a forerunner of the storm which nearly three centuries later was to break on the head of Galileo.

III

In the second half of the fourteenth century, we have the beginning of the period frequently assigned to the Renaissance. With the pioneer work of Petrarch, who was not a scientist, this is not the place to deal. Indirectly, however, the movement with the beginning of which he is so closely identified was of tremendous importance to the advancement of science. Petrarch, in seeking to recover the spirit of the ancient classical world, in applying to historical documents the modern scientific method, in his refusal to accept Aristotle's au-

thority as final and in his ridicule of the universities, the citadels of scholasticism, did yeoman service to the cause of science. And yet neither in the fourteenth nor in the fifteenth nor even in the sixteenth centuries was there any great outburst of what might be called modern science. There was progress, to be sure, but advances were so slow that it is worth while to consider some of the causes for the apparent lag of science behind other fields. How was it that during a period in which there was such a remarkable orientation of men's minds, the rebirth of modern science was so slow?

Some of the causes have already been indicated; a few others may be briefly mentioned. In the first place, during the revival of learning, scholars were engaged in recovering ancient manuscripts; their joy to some extent was that of the collector; their interest was in the glory of a past civilization as much as in the world about them. The translations, moreover, were frequently faulty; even Petrarch was not a Greek scholar and it was not until after his day that Latin translations were replaced by original and more accurate Greek manuscripts. There was a tendency to substitute the commentary on scientific works for a direct appeal to nature. Even granted a genuine interest in science on the part of many scholars, time was necessary for the recovery and the assimilation of the work of the Greeks. Then, too, as some one has said, it is quite possible to read the classics without becoming forthwith Hellenistic in one's attitude of mind—a remark, by the way, as applicable to the twentieth century as to the fourteenth and fifteenth. A striking example of this is found in the fact that as the intellectual class gradually included many who were by no means theologians, Aristotle became as great an authority with the skeptics as with the scholastics. Aristotle, says Harvey as late as the seventeenth century, "has always such weight with me that I never think of differing from him inconsiderately."

In the next place advances which can only be made by the method of experiment and of observation are necessarily slow. Even in the twentieth century, with its wealth of aids to investigation, years may elapse before accumulated facts are correlated in some underlying principles. How much more slow, then, in days when the telescope and the microscope had yet to be invented; when there were no thermometers, no air pumps; when the pendulum clock had not come into existence; when for part of the time, there was no printing press. A great deal of preparatory work was a necessary condition for any striking scientific advances. Telescopes could not be invented without a previous study of lenses; for many problems in subjects like astronomy improved mathematical processes were necessary; and in the same subject, the laws governing the movements of heavenly bodies could not be understood until Galileo and his contemporaries had laid the foundations of the science of mechanics.

Finally, there was much in what we might call the zeitgeist of these centuries which operated against the development of a pure science. Few men can rise entirely above the common prejudices of their day and generation, and throughout the Renaissance period many things now scoffed at by science were accepted without question. A good illustration is found in the following quotation from Taylor's "Thought and Expression in the Sixteenth Century":

> George Agricola in 1556 published his *De re metallica*, an excellent and complete treatise upon everything connected with the mining and metallurgy of the time in Germany. It treats of the origin of veins and ore deposits, and discredits the use of divining-rods to discover veins of metal. But it recognizes devils, along with bad air and venomous ants, as among the pests encountered in mines.

Here is another example in the field of medicine, "At Florence, the very heart of classical enlightenment, in the year 1494, when Lorenzo de' Medici lay on his death bed, the last medicine given him was a draught of pulverized jewels." Still another is found in the case of the famous surgeon, Ambrose Parée, who, in spite of his deserved rank as a pioneer of modern surgery, believed in sorcery as a possible cause of wounds. Numerous other illustrations could be given to show that few of even the most advanced scientists of this period were able to throw overboard completely belief in supernatural agencies. This is perhaps not surprising when we reflect that in the present day we are not entirely free from the same attitude. It is not difficult to find those who can not be persuaded to walk under a ladder, or those who, when the table salt spills, immediately throw some over their left shoulder. People can still be found who carry horse chestnuts on their persons as a cure for rheumatism, while only a few months ago the writer picked up a newspaper with a full page horoscope for the year of our Lord 1925.

Belief in magic, charms and supernatural agencies must not be confused with the practices of alchemy and astrology, two semi-scientific pursuits characteristic both of the latter middle ages and the Renaissance. In both of these we have at once a help and a hindrance to the cause of pure science. In spite of the atmosphere of secrecy, of nonsensical symbolism, at times even of fraud and deception which frequently pervaded the work of the alchemists, their number included many who were undoubtedly the founders of modern chemistry. If no great principles were discovered, alchemy was responsible for many chemical methods and processes which time does not permit to discuss.

What alchemy was to chemistry, astrology was to astronomy. The influence of stars and planets on the fortunes of men could not be discovered without accurate knowledge of the positions and movements of the heavenly bodies. Astrology, therefore, was a stimulus to the cause of observational astronomy and herein is possibly one reason why so much of the pioneer work in science was in that field. On the other hand, the casting of horoscopes is not exactly consistent with the aims and methods of modern science and such pursuits did little to hasten its arrival. If, however, progress during the Renaissance was slow, it was real, and a brief reference will now be made to the work of a few of the outstanding pioneers of that period.

IV

The first of these is Leonardo da Vinci, painter, botanist, biologist, physiologist, anatomist, physicist and engineer. In this article our interest is not so much in his actual achievements as in his attitude towards the world of nature. He was the very antithesis of those who would deduce scientific principles from faulty premises. For him, *esperienza,* a combination of observation, experiment and investigation, was the only method of arriving at an understanding of the phenomena of nature. "Those sciences are vain and full of errors," he says, "which are not born of esperienza, mother of all certitude . . ." "I will make esperienza before I proceed, because my intention is first to set forth the facts and then demonstrate by reason why such esperienza is constrained to work in such fashion, and this is the true rule to be followed by the investigators of natural phenomena." Not only did Leonardo both preach and practice to an amazing degree esperienza, but at the same time he emphasized the importance of the *quantitative* side of physical investigation. "There is no certitude where some one of the mathematical sciences can not be applied." As an example we may cite

Leonardo's interest in flying machines and in the flight of birds. Observation alone was not sufficient for a knowledge of the laws of flight. "The bird," he says, "is a machine working through mathematical law."

And so this marvelous man in a highly scientific fashion examined experimentally almost everything which came into his ken. For exact lines in painting a knowledge of anatomy is desirable. Nothing will do for Leonardo except a direct study by dissection of the human body, and that, too, in defiance of the canons of the church. He sees in the moon an object for investigation and in his notes we find the suggestion, "construct glasses to see the moon magnified"—this, mark you, over one hundred years before the invention of the telescope. To turn from the schoolmen to Leonardo da Vinci is like going out into the fresh air from a hot and stuffy room.

From Leonardo we turn to Copernicus, the first of a series of five men whose work brings us into the full daylight of modern physical science. Nicolaus Copernicus, a native of Poland, whose studies in medicine, astronomy, mathematics and theology had taken him successively to Cracow, Vienna, Bologna, Padua, Ferrara and Rome, eventually was made canon of Frauenberg, where he spent the last thirty years of his life. There he found time not only for his duties as priest but also for those of doctor and astronomer. Although neither great as an experimenter nor a giant in intellect, he occupies a place in the front rank of the pioneers of science. As every one knows he came to the conclusion that the sun, not the earth, was the center of the solar system, that we have to deal with a heliocentric not a geocentric system. The idea was not an original one—"I searched among the books of the philosophers," he says, "until I found that some of them conceived the earth to move"—but it was certainly revolutionary. Just think for a moment what it meant. The schoolmen and all later theologians had set the seal of an infallible authority on the Ptolemaic system. Theology and science had combined to construct a soul-satisfying scheme which it became heresy to question. Surrounding the earth enthroned in the center of the universe were nine rotating spheres, seven for each of the moon, mercury, venus, sun, mars, jupiter, saturn, the eighth for the fixed stars, the ninth the crystalline sphere—the primum mobile. Beyond was the tenth heaven, the immovable empyrean, wherein was the throne of the Almighty. This system, moreover, as elaborated by Ptolemy, was able to account at least roughly for the observed motion of the planets, to predict eclipses and to provide necessary astronomical data for the church calendars. And in the face of all this a quiet studious monk dares to suggest that the earth with man on it be moved from its all-important central position. His reasons are based on a thoroughly scientific method. As he explains in the preface to his famous book "De Revolutionibus Orbium Celestium," dissatisfaction with the "traditional mathematical doctrine concerning the paths of the heavenly bodies" led him to adopt an idea suggested many centuries before, and, as he puts it, "to try whether on the theory of the motion of the earth more satisfactory explanations than heretofore might not be found for the movements of the heavenly bodies." This theory he put to the test with the conclusion "that if the movements of the other planets were referred to the motion of the earth in its orbit and reckoned according to the revolution of each star, not only could their observed phenomena be logically explained, but also the succession of the stars, and their size, and all their orbits and the heavens themselves would present such a harmonious order that no single part could be changed without disarranging the others and the whole uni-

verse." It was as if the mantle of Hipparchus had fallen on the shoulders of Copernicus. The application of the modern scientific method had led him to the formulation of a new and revolutionary theory which better fitted the facts. And what were the consequences? Strangely enough, there was apparently no great immediate outburst of opposition. To be sure there was opposition, as will be sufficiently evident from the following comment of Luther: "The fool will overturn the whole art of astronomy. But as holy writ declares, Joshua commanded the sun to stand still and not the earth." But there was no immediate conflict for reasons some of which are not hard to find. Copernicus, who for some years had quietly communicated his ideas to interested people, lived only long enough to see the completion of his famous book. He was unaware that a false paragraph had been added to his preface by a Lutheran friend to the effect that the theory advanced was only a hypothesis, a kind of picture puzzle solution of this big astronomical problem, but by no means a claim to be the actual truth. This spurious preface, combined with the friendship of a cardinal of the church, doubtless did much to disarm criticism. His case, moreover, was not yet strong enough. More accurate observations and a knowledge of the mechanics of moving bodies were necessary to make the case for the Copernican theory so strong that an alternative was not possible.

Accurate observations were provided by Tycho Brahe, a native of Denmark and one of the most remarkable astronomers who has ever lived. A man who did not accept the Copernican theory, who saw in the conjunction of Jupiter and Saturn a cause for the great plague, who all his life dabbled in alchemy and astrology—such a man seems scarcely worthy to be ranked with Copernicus. And yet his experimental work in point of accuracy is so much in advance of any of his predecessors that he well deserves the name of the first Astronomer Royal. Private means, combined with praiseworthy aid from Frederick II of Denmark, enabled him to construct the castle of Uranibourg, a palatial observatory where for over twenty years with improved instruments Tycho corrected and extended existing astronomical observations to an accuracy hitherto undreamed of. So renowned was this man and his observatory that we read of an eight-day visit to Uranibourg by James I of England on the occasion of his marriage with Anne of Denmark.

After the death of Frederick, evil days fell upon Tycho and we read no more of his famous castle. In 1599, however, he was invited by the emperor of Bohemia to settle in Prague, where he spent the remaining two years of his life. In this brief sketch these two years would not be mentioned at all were it not for one outstanding event. During that time a young German by the name of Kepler came to work under Tycho Brahe. Now this young man, although no great experimenter, had a passion for trying to get beneath facts. Is there any law governing the distances of the various planets from the sun? Is there any reason why there should be only six? How are the periodic times related to their corresponding distances? Questions such as these had been exercising the mind of Kepler before he came to work with Tycho, and to some of them he had already given tentative answers in a book published in 1597. To test his theories, however, more accurate observations were necessary, and so he went to Tycho Brahe. A man with a passion for underlying principles, equipped with keen scientific imagination and mathematical ability, avails himself of the careful work of a brilliant experimenter. The result is not surprising. After years of patient toiling, of many hypotheses tried and cast aside because they did not fit the facts, the true law is discovered. It

is very brief, and very simple—planets move in ellipses with the sun in one focus. It is difficult for those who have had little training in physical science to appreciate the full beauty of this sweeping generalization which fitted the facts to the high order of accuracy attained by Tycho Brahe. One very important point, however, can readily be appreciated, and that lies in the substitution of the ellipse for the circle. Aristotle had taught, and for centuries it had been accepted, that the true and perfect motion was circular. Now a simple circular motion does not explain the motion of the planets and both in the Ptolemaic system and the Copernican, combinations of circles known as epicycles—wheels within wheels, so to speak—had been used. Copernicus had reduced the number of epicycles from 79 to 34, and in other respects wrought much simplification. Kepler, however, in his discovery of the simple elliptical law, at one stroke did away with the whole system of epicycles and at the same time struck another fatal blow at the authority of Aristotle. It is little wonder that his joy over this and other discoveries is unbounded. "Nothing holds me," he states after solving a problem which had proved too much for Alexandrian astronomers, "nothing holds me, I will indulge in my fury; I will triumph over mankind by the honest confession that I have stolen the golden vases of the Egyptians to build up a tabernacle for my God, far away from the confines of Egypt."

Just about the time Kepler was making his brilliant investigations, an Italian contemporary, Galileo Galilei, a native of Pisa, was startling the world with results obtained by looking at the heavens, for the first time, through a telescope. Galileo began his career with the double advantage of a liberal education, including classics and r athematics, and of a home influence which stood for open inquiry, untrammeled by the authority of tradition. Although in early years destined for business, a wise father sent him to the university to study medicine. But he was one of nature's born investigators, and it was not long before he found the natural outlet for his talents in the study of physical science. Seldom has such study brought so rich a reward. Even when a lad of eighteen, Galileo's genius for experimental investigation is evident in his observation of the swings of the great lamp in the Cathedral of Pisa, and consequent discovery of the isochronism of the pendulum, a law on which the construction of all pendulum clocks is based. This marked the beginning of a career in which the modern scientific method of observation and experiment, of induction followed by deduction and experimental verification, was constantly in evidence. Do bodies fall the faster, as Aristotle maintained, the heavier they are? Experiment and see, says Galileo, and so he climbs to the top of the famous leaning tower of Pisa, drops simultaneously a one pound mass and a hundred pound mass. They strike the ground together, and thus in the course of a few minutes the learned gentlemen who constitute the faculty of the University of Pisa receive a convincing demonstration of the fallacy of the 2,000 year old maxim of Aristotle's. Such experiments are followed up by careful investigations of the laws of moving bodies, laws with which all students of mechanics nowadays must be familiar. In other branches of physics the same sound methods are applied; in thermometry, in hydrostatics, in acoustics, in optics—whatever the field, it is approached in the same way. The modern physicist, in reading Galileo's writings, feels that spiritual kinship which exists between men whose aims and methods are the same.

But it is in the field of astronomy that the startling discoveries are made. Galileo, hearing of the existence in Holland of an instrument which magnifies distant objects, constructs a telescope. A new world is the result. "Many noblemen and senators, though of advanced age, mounted to the top of one of the highest towers to watch the ships which were visible through my glass two hours before they were seen entering the harbor, for it makes a thing fifty miles off as near and as clear as if it were only five." The telescope is directed to the heavens and a wealth of new knowledge is available for the mind of man. There are hills and valleys on the moon; not only are there spots on the sun, but they move; Saturn has rings; Jupiter has three or four satellites which revolve about her, and Venus exhibits phases just like the moon. Predictions of Copernicus are verified and for all who have eyes to see there is ample evidence of the truth of his view of the solar system. But there are those who, having eyes, see not, those who harden their hearts even in the face of cold facts, and these were not wanting in Galileo's time. His discoveries were too much for the reactionaries. Some refused to look through the telescope; others said that, while it might be all right for terrestrial objects, it could not be trusted for heavenly. Some tried to dispose of the matter by foolish argument. And the matter did not end even there. The Inquisition took Galileo in hand. It will be noted that as the truth of the Copernican theory became more and more evident to men with open minds, the opposition of the reactionaries increased. Copernicus' famous book was not immediately placed on the prohibited list; a book of Kepler's, giving a clear statement of the theory, was, however, at once put under the ban, while for Galileo was reserved the distinction of being persecuted. After a period, the details of which it is as well to omit, Galileo, a broken man of seventy years, finally recanted. "I abjure, curse and detest the said heresies and errors"—this from the lips of a man who had once said "It is not in the power of any creature to make them to be true or false or otherwise than of their own nature and in fact they are."

But no one knew better than Galileo that truth can not ultimately be suppressed. The apparent victory of the reactionaries might delay but it could not stop the forward march of science. All along the line the dead weight of authority and tradition was being cast aside. In anatomy Vesalius had broken with those who were satisfied with Galen and Hippocrates; in zoology and botany, Gesner had become the pioneer of the moderns; in 1600 Gilbert had published an account of his investigations in electricity and magnetism, and in 1628 Harvey announced his discovery of the circulation of the blood. Reactionary influences continued, indeed they are still with us, but they could not destroy the new spirit which was at work in the world. In the year in which Galileo died, Isaac Newton was born. With that great genius we have left the Renaissance far behind and found ourselves in the full daylight of modern science.

THE FRIENDSHIP OF TWO OLD-TIME NATURALISTS

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"Thoreau would be a splendid entomologist if he had not been spoiled by Emerson." This remark was once made by Dr. Thaddeus William Harris concerning one of his most valued personal friends, Henry David Thoreau. Perhaps the words were spoken whimsically or in jest, but nevertheless it is probable that they contain a germ of truthfulness regarding the estimate by Dr. Harris of his friend.

There are few of the present-day entomological fraternity who possess sufficient antiquarian tastes to take the time or trouble for anything like a serious consideration of the lives of the individuals who composed the historical background of economic entomology in this country. These few, no doubt, have realized somewhat vaguely that Harris and Thoreau were contemporaries. Yet scarcely any appear to have appreciated the fact that these men were close personal friends and that this relationship in some degree was of so unique a character as to be worthy of present-day attention.

Doubtless it will possess a value in these hectic times of large appropriations, of extensive personnel and of extreme specialization to review briefly and ponder some of the existing records which stress the more outstanding characteristics that combined to make up the splendid comradeship which existed between these two old-time naturalists. It may be helpful in these strenuous days of graphs and charts to endeavor to visualize in some degree their serene lives and philosophy, their placid methods of study, all unhaunted by present-day mathematical formulae or logarithmic tables, and their broad outlook upon, and cosmopolitan interest in, all nature's phenomena. A consideration of their lives and achievements may give one a feeling akin to sympathy for some of those who make a plea that there be, in some degree, a renaissance from the present-day hair-splitting specialization to some of the ideals of the old-time naturalist.

During a considerable portion of the active working period of the life of Dr. Harris there probably were not a half dozen people in this entire country who were sufficiently interested in the study of entomology to be considered worthy of the name of entomologist. Any adequate consideration of him, therefore, during that time necessarily would include a history of American entomology for the same period, and this fact gives especial interest to his career and to the friendships he formed with Thoreau, Agassiz and others of his time.

Born in Dorchester, Massachusetts, November 12, 1795, Harris was twenty-two years older than his friend Thoreau. The elder Harris, his father, was a librarian at Harvard, a Congregational minister, a learned antiquarian and author of a number of religious and scientific works, among which was an elaborate work on the "Natural History of the Bible." It seems that his mother also was more or less interested in matters entomological, because for some years she was diligent in rearing silkworms. The home environment of the

youth, therefore, formed a fitting background for subsequent scientific work, and it is known that, true to form, the lad early began to make a permanent collection of insects. He was graduated from Harvard in 1815, devoted himself to the study of medicine, took his medical degree in 1820, married shortly thereafter and then began medical practice at Milton, Massachusetts.

It does not appear that he ever became really attached to his profession or attained a really lucrative medical practice, and eventually his pecuniary anxieties became so great that, after considerable strenuous casting about, he secured an appointment in 1831 as librarian at Harvard College. This position he held during the remainder of his life. The daily routine of this work was of a character to render it congenial to one having such methodical and accurate habits of thought as Dr. Harris. The library was very small at the inception of his period of services, and limited funds gave little subsequent opportunity for its increase, especially along scientific lines, although it grew from thirty thousand to sixty-four thousand volumes during his lifetime.

For some years he was also in charge of the annual course of lectures on "natural history," with special lectures on botany. Eventually he formed a private class in entomology for the benefit of the very few who cared to attend it. According to the recollections of one of his students, Dr. Samuel H. Scudder,[1] these classes must have been very delightful, though progress was slow, and the class did not go beyond the Coleoptera. "Dr. Harris," he says, "was so simple and eager, his tall, spare form and thin face took on such a glow and freshness as he dwelt so lovingly on antennae and tarsi, and as he so fondly handled his little insect-martyrs, that it was enough to make one love the study for life!"

It was only by vast labor and pains during his spare time that Dr. Harris was able to accumulate for his study a working collection of specimens and an adequate library for his researches. The resources of the college library and his own collection were pitifully inadequate for use in a really serious study of entomology, and it therefore became necessary for him to prepare from borrowed material an extended series of manuscript indexes of a large number of the principal systematic works on Lepidoptera, Coleoptera and other orders, as well as general works on entomology. These manuscript books eventually became extensive in number and are now in the archives of the Boston Society of Natural History. "So beautifully executed is all this laborious work," says Scudder, "that it is as easily accessible as print, though the earlier sheets are yellow and torn." Since all this work was gratuitous and entirely independent of his regular duties as librarian and instructor, one can well imagine that a man of meager pecuniary means with a family of twelve children to share his time and resources must have had very little time or money for the pursuit of such a hobby, no matter how engrossing or fascinating such an avocation was certain to be to a person of his training and tastes.

In 1831 he prepared a catalogue of insects, which was published as an appendix to Hitchcock's "Massachusetts Geological Report." Later he was appointed by the state of Massachusetts a member of a commission to make a more thorough geological and botanical survey of the state. It was while he was performing this work that he brought together his noted classic, "Report on Insects Injurious to Vegetation." This report was first published in full in 1841, the section on beetles previously

[1] Scudder, S. H. (Ed.) "Entomological Correspondence of Thaddeus William Harris," Boston, Bost. Soc. of Nat. Hist. 1869.

having appeared in 1838. In 1842 it was reprinted as "treatise" instead of "report" and again reprinted in a revised form in 1852. The entire sum received from the state for this labor was $175. The work was reprinted by the state after his death in its present form, with wood engravings so beautifully executed as to mark an epoch in that art. Says Dr. L. O. Howard[2] in 1899:

> The practical value of Dr. Harris's work has been vast. His scientific reputation has steadily grown. His book is to-day as valuable as it was when first written, more than fifty years ago. On entering any entomological workshop in the land the first book that will catch the eye upon the desk is a well worn copy of the "Treatise upon insects injurious to vegetation."

In studying the writings of Dr. Harris, it will be found that his generalizations have stood well the test of subsequent and more elaborate research. It has been said of Harris that his "insight into nature and the relations of affinity, although they might be based upon a meager series of natural objects, was truly enviable." It seems, however, a great loss to the advancement of knowledge that the maturity of Dr. Harris's powers should have been diverted for so much of the time from his zoological studies and that such a large part of his time should have been, as it were, wasted on routine drudgery which might have been performed by some mediocre helpers. Yet, with all its disappointments and misfits, his life could hardly be regarded as unhappy. If he could not be wholly a naturalist, yet there is no doubt that he found enjoyment in being a librarian. In view of his inheritance and his training he seemed to be born with a librarian's interest in alcoves and pamphlets and endless genealogies. It is known that he kept his official records with exquisite accuracy and described his methods on occasions to fellow-librarians as sympathetically and as lovingly as if he were describing a most delicate chrysalis.

Although the general health of Dr. Harris was good during the greater part of his life, yet the habitual overwork to which he was subjected led to occasional nervous exhaustion and to severe headaches. During his last years he was the victim of heart disease and pleurisy, with other complications. His last illness began in November, 1855, and he died of heart disease on January 16, 1856, in his sixty-first year.

The impossibility of attempting to compress within a few brief paragraphs an adequate outline of any human life is realized with an especial feeling of despair in the case of such a strongly marked individuality as was that of Thoreau. Born near Concord, Massachusetts, July 12, 1817, of American parentage descended from Scotch and French ancestry, Thoreau spent his childhood and youth in poverty, though in a pastoral country amid scenes of placid beauty. In this environment he early became passionately devoted to a study of the varying aspects of nature and to the delights of solitude, and when only twelve years of age he began to make collections for Agassiz, who had just then arrived in America. During his entire life the woods and meadows, hedges and swamps, streams and lakes of his beloved Concord were sources from the sympathetic study of which he obtained a fund of rare knowledge and to which he constantly turned for consolation and inspiration. He was graduated from Harvard in 1837 and for some years thereafter was engaged in teaching. Later he became a professional surveyor, which work was more congenial than the schoolroom in that it gave him a longed-for opportunity to tramp over the fields and scramble over the hills and to devote

[2] Howard, L. O. "Progress in Economic Entomology in the United States." Yearbook U. S. Dept. Agriculture, 1899, pp. 135–156. 1900.

long hours to intensive study of plants, birds, insects and other natural phenomena. His observations were recorded daily in his journal, and this writing was done with a sympathy, an insight and a fidelity to detail seldom equalled elsewhere and the contents often were couched in language of rare beauty. This journal, in its original form consisting of thirty large manuscript volumes, published in 1906, comprises over 7,800 printed octavo pages. It was begun in 1837 in his twentieth year, continued uninterruptedly down to his death and covered a period of twenty-five years. In some respects it is probably one of the most extraordinary productions in American literature. During the later years of his life, Thoreau spent the greater part of his time as lecturer and author. His "Week on the Concord and Merrimack Rivers," issued in 1849, is a narrative of a boat trip taken with his brother in August, 1839, and is full of admirable description and minute observations of nature, with occasional digressions into philosophy, history and classical literature. His second book, "Walden," issued in 1854, is an account of the author's residence for two years, beginning in 1845, as a naturalist and writer, in a tiny hut on the shores of a small pond near his native village. This is his most popular work and is "recognized as one of the most original and sincere publications in American letters and one of the most genuine of woodland books." Only these two volumes were issued during his lifetime, though others were posthumously edited from the journal accounts of some of his short expeditions over New England, notably "Excursions," 1863; "The Maine Woods," 1864; "Cape Cod," 1865; "Spring," 1881; "Summer," 1884; "Winter," 1888, and "Autumn," 1892. The increasing interest in Thoreau and the growing appreciation of the permanent value of his work on the part of the public were evidenced by the publication of the Riverside edition of his works in eleven volumes in 1896, and the new and complete "Walden" edition in twenty volumes in 1906.[3] This edition includes the publication, for the first time, of the journal in its entirety as written and this comprises fourteen of the volumes. Some of his best essays are perhaps not to be excelled in American literature, and, as one writer has put it, "it may be doubted whether the work of any of his contemporaries is wearing so well."

Said Emerson concerning him:

> It was a pleasure and a privilege to walk with him. He knew the country like a fox or a bird, and passed through it as freely by paths of his own. He knew every track in the snow or on the ground, and what creature had taken this path before him. Under his arm he carried an old music book to press plants; in his pocket his diary and pencil, a spy-glass for birds, microscope, jack-knife and twine. He drew out of his breastpocket his diary and read the names of all the plants that should bloom on this day, whereof he kept account as a banker when his notes fall due. The cypripedium not due till to-morrow. He thought if waked up from a trance in this swamp, he could tell by the plants what time of the year it was within two days.

There were people who criticised Thoreau as being an eccentric loafer or an impractical dreamer. It is not known who all these were. Apparently their sole claim to immortality lies in the fact that they criticised Thoreau. "The cur barks at the moon, but the moon still shines on." On the other hand, scarcely ever was a man more fortunate in the character of his friendships or more profoundly influenced by them. Perhaps, too, there scarcely ever was a man more fully appreciative of them. In addition to Harris, it is known that Thoreau was on terms of more or less intimate friendship with, and that a number of his field and woodland expeditions were taken in

[3] "The Writings of Henry David Thoreau." Walden edition, 20 volumes. Boston. Houghton. 1906.

the company of, such stimulating and inspiring associates as Ralph Waldo Emerson, Louis Agassiz, William Ellery Channing, A. Bronson Alcott, Margaret Fuller, Edward Hoar, Louisa May Alcott, Nathaniel Hawthorne, Frank B. Sanborn,[4] Horace Greeley, Walt Whitman, Daniel Ricketson, H. G. O. Blake and Thomas Cholmondeley. One might envy those old-time observers both their associations and the comparatively virgin field in which they worked did not one realize how truly to-day the "great ocean of truth still lies all undiscovered before us."

Curiously enough, in 1861, Thoreau, who had spent the greater part of his life in the open, contracted tuberculosis—a fact in defiance of our modern notions regarding control of that disease. After a heart-breaking trip to Minnesota in vain search for a more favorable climate, he returned to Concord and died there on May 6, 1862, in his forty-fifth year, having outlived his friend by only seven years. At the time of his funeral Emerson said of him:

> The country knows not yet, or in the least part, how great a son it has lost. His soul was made for the noblest society; he had in his short life exhausted the capabilities of the world; wherever there is knowledge, wherever there is virtue, wherever there is beauty, he will find a home.

The temptation to a compiler is very great to quote copiously from the references in Thoreau's journal to his friendship with Dr. Harris. Limitations of space and a wholesome fear of the editorial blue pencil, however, forbid more than the inclusion of a few of the more typical records of the visits and conversations of these two friends. It is easy from these scattered entries to visualize the free and easy comradeship which existed between them and to apprehend something of the zest and delight with which at every meeting they discussed and pored over their entomological treasures. Especially evident always are the care manifested by that born teacher, Dr. Harris, in imparting knowledge to his younger associate fully and clearly from his vast fund of information and the sympathetic interest manifested by him in the identification of material brought in to him from time to time in earlier years by his protégé. The following passage, under date of July 26, 1852, from the Journal (v. 4, pp. 259–260), is typical of this:

> Went to Cambridge and Boston to-day. Dr. Harris says that my great moth is *Attacus luna*; may be regarded as one of several emperor moths. They are rarely seen, being very liable to be snapped up by birds. Once, as he was crossing the College yard, he saw the wings of one coming down, which reached the ground just at his feet. What a tragedy! The wings came down as the only evidence that such a creature had soared—wings large and splendid, which were designed to bear a precious burden through the upper air. So most poems, even epics, are like the wings come down to earth, while the poet whose adventurous flight they evidence has been snapped up by the ravenous vulture of this world. If this moth ventures abroad by day, some bird will pick out the precious cargo and let the sails and rigging drift, as when the sailor meets with a floating spar and sail and reports a wreck seen in a certain latitude and longitude. For what were such tender and defenseless organizations made? The one I had, being put in a large box, beat itself—its wings, etc.—all to pieces in the night, in its efforts to get out, depositing its eggs, nevertheless, on the sides of its prison. Perchance the entomologist never saw an entire specimen, but as he walked one day, the wings of a larger species than he had ever seen came fluttering down. The wreck of an argosy in the air. He also tells me the glow worms are first seen, he thinks, in the latter part of August; also that there is a large and brilliant glow worm found here, more than an inch long, as he measured it on his finger, but rare.

It appears that other and random topics of conversation on such visits also made sufficient impression upon the mind of the writer to be recorded, for, on January 1, 1853,[5] he says:

[4] Sanborn, F. B., "Life of Henry David Thoreau." Boston. Houghton. 1917.

[5] "Journal," v. 4, pp. 439–440.

Being at Cambridge day before yesterday, Sidley told me that Agassiz told him that Harris was the greatest entomologist in the world, and gave him permission to repeat his remark. As I stood at the top of a ladder, he came along with his hand full of papers and inquired, "Do you value autographs?" "No, I do not," I answered slowly and gravely. "Oh, I didn't know but you did. I had some of Governor Dunlap," said he, retreating.

And again, on February 9, 1853:[6]

At Cambridge to-day. Dr. Harris thinks the Indians had no real hemp but their apocynum, and, he thinks, a kind of nettle, and an asclepias, etc. He doubts if the dog was indigenous among them. Finds nothing to convince him in the history of New England. Agassiz asked him what authority there was for it. Thinks that the potato which is said to have been carried from Virginia by Raleigh was the ground nut (which is described, I perceived, in Debry (Heriot?) among the fruits of Virginia), the potato not being indigenous in North America, and the ground-nut having been called wild potato in New England, the north part of Virginia, and not being found in England. Yet he allows that Raleigh cultivated the potato in Ireland.

There are also occasional entries, which at first may come as a bit of surprise to a professional entomologist, that the young man should find it necessary to go to his mentor for identification of material now considered exceedingly common. It should be realized, however, that notes like the following were made seventy-two years ago and concerned species that possibly may have been comparatively rare at that time:

To Haverhill via Cambridge and Boston. Dr. Harris says that that early black-winged buff-edged butterfly is the *Vanessa antiopa*, and is introduced from Europe, and is sometimes found in this state alive in winter. The orange-brown one with scalloped wings, and smaller somewhat, is *Vanessa progne*. The early pestle-shaped bug or beetle is a *Cicindela*, of which there are three species, one of them recognized from a semicolon-like mark on it.[7]

To Boston. Channing says he saw skater insects to-day. Harris tells me that those gray insects within the little log forts under the bark of the dead white pine, which I found about a week ago, are *Rhagium lineatum*.[8]

Went to Cambridge to court. Dr. Harris says that my cocoons found in Lincoln in December are of the *Attacus cecropia*, the largest of our emperor moths. He made this drawing of the four kinds of emperor moths which he says we have. The *cecropia* is the largest. The cocoon must be right end uppermost when they are ready to come out. The *A. promethea* is the only moth whose cocoon has a fastening wound around the petiole of the leaf, and round the shoot, the leaf partly folded around it. That spider whose hole I found, and which I carried him, he is pretty sure is the *Lycosa fatifera*. In a large and splendid work on the insects of Georgia, by Edwards and Smith (?) near end of last century, up-stairs, I found plates of the above moths, called not *Attacus*, but *Phalaena*, and other species of *Phalaena*. He thinks that small beetle, slightly metallic, which I saw with grubs, etc., on the yellow lily roots last fall was a *Donax* or one of the *Donasia* (?).[9]

One can well picture the delight and the enthusiasm with which congenial spirits would discuss a finding of such momentous importance as the following:

Dr. Harris described to me his finding a new species of *Cicindela* at the White Mountains this fall, the same of which he had found a specimen there some time ago, supposed to be very rare, found at Peter's River and Lake Superior; but he proves it to be common near the White Mountains.[10]

Or the intensity of interest with which they would debate some such point as the following:

Saw at Farmer's, his snow-grubs—the same I had seen (Vide back). Harris, in this week's *New England Farmer*, thinks, on comparing them with English plates, that they are the larvae of one of the species of cranefly (*Tipula*). I saw some still in F's pasture. Did they come out from the roots of grass prematurely in the winter, and so become food for birds?[11]

[6] "Journal," v. 4, p. 491.
[7] April 11, 1853, "Journal," v. 5, p. 109.
[8] March 13, 1854, "Journal," v. 6, p. 166.
[9] January 19, 1854, "Journal," v. 6, p. 73.
[10] Nov. 28, 1853, "Journal," v. 5, pp. 521–522.
[11] April 1, 1854, "Journal," v. 6, p. 181.

Or, again, their penchant for comparison of data like the entry for June 13, 1854:[12]

Caught a locust—properly harvest fly (*Cicada*)—drumming on a birch which Bacon and Hill (of Waltham) thinks like the *septendecim*, except that ours has not red eyes but black ones. Harris's other kind, the dog-day *Cicada* (*canicularis*), or harvest-fly. He says it begins to be heard invariably at the beginning of dog days; he (Harris) heard it for many years in succession with few exceptions on the 25th of July.

And, January 16, 1855:[13]

To Cambridge and Boston. Carried to Harris the worms—brown, light striped, and fuzzy black caterpillars (he calls the first also caterpillars); also two black beetles; all which I have found within a week or two on ice and snow; thickest in a straw. Showed me, in a German work, plates of the larvae of dragon flies, and ephemarae, such as I see—or their cases—on rushes, etc., over water. Says the ant-lion is found at Burlington, Vermont, and *may* be at Concord.

The creaking or shrilling of crickets long appeared to possess a fascination for Thoreau, for he has referred to it again and again in his writings in entries which were scattered over a long period of years. Occasionally he speaks of it in words of rare beauty and high poetic import. A large volume might well be filled with quotations from his Journal on this topic alone. Perhaps the following, chosen at random, will indicate their general tenor:

As I climbed the hill again toward my old bean-field, I listened to the ancient, familiar, immortal, dear cricket sound under all others, hearing at first some distinct chirps; but when these ceased I was aware of the general earth-song, which my hearing had not heard, amid which these were only taller flowers in a bed, and I wondered if behind or beneath this there was not some other chant yet more universal. Why do we not hear when this begins in the spring? and when it ceases in the fall? or is it too gradual?[14]

And:

Be ever so little distracted, your thoughts so little confused, your engagements so few, your attention so free, your existence so mundane, that in all places and in all hours you can hear the sound of crickets in those seasons when they can be heard. It is a mark of serenity and health of mind when a person hears this sound much—in streets or cities as well as in fields. Some ears never hear this sound; are called deaf. Is it not because they have so long attended to other sounds?

Why was there never a poem on the cricket? Its creak seems to me to be one of the most prominent and obvious facts in the world, and the least heeded. In the report of a man's contemplations I look to see somewhat answering to this sound.

It is evident that Thoreau and Harris included the topic in some of their long all-embracing conversations. Under date of October 19, 1857,[15] is this entry:

Harris says the crickets produce their shrilling by shuffling their wing-covers together *lengthwise*. I should have said it was sidewise, or transversely to the insect's length, as I looked down on it. You may see these crickets now everywhere in the ruts, as in the cross-road from the turn pike to the Great Road, creeping along, or oftenest three or four together, absorbed in feeding on, *i.e.*, sucking the juices of, a crushed companion. There are two broad ruts made by oxcarts loaded with muck, and a cricket has been crushed or wounded every four or five feet in each. It is one long slaughter-house. But as often as a cart goes by, the survivors each time return quickly to their seemingly luscious feast. At least two kinds are there.

Occasionally he dwells in characteristic strain upon sounds made by other insects. Can we imagine a twentieth century orthopterist at the close of a busy day in the field methodically making an entry like this in his notes:[16]

The crackling flight of grasshoppers is a luxury; and pleasant is it when summer has once more followed in the steps of winter to hear scald cricket piping a Nibelungenlied in

12 "Journal," v. 6, p. 348.
13 "Journal," v. 7, p. 116.
14 June 13, 1851, "Journal," v. 2, p. 254.
15 "Journal," v. 10, p. 108.
16 "Journal," v. 1, p. 57.

the grass. It is the most infinite of singers. Wiselier had the Greeks chosen a golden cricket, and let the grasshoppers eat grass. One opens both his ears to the invisible, incessant quire, and doubts if it be not earth herself chanting for all time.

There is no doubt but that matters other than those entomological engrossed a portion of their attention when together. Witness the entry under date of December 7, 1854:[17]

Harris tells me that since he exchanged a duplicate Jesuit Relation for one he had not with the Montreal men, *all* theirs have been burnt. He has two early ones which I have not seen.

One thinks, parenthetically, that the two friends surely would have gloated over it could they have been permitted to live long enough to see and study the monumental translation of that voluminous mine of historical and biological information, "The Jesuit Relations," which work has been so ably performed in our own generation by that eminent historian, Reuben G. Thwaites.

It will be remembered in this connection that Dr. Harris, by virtue of his position as librarian, was often consulted as an expert in genealogical matters and that his interest in the subject was very real is evidenced by the fact that at the time of his death he had in course of preparation a very elaborate genealogical history of the Mason family. If he was forbidden by a perverse fate to be entirely an entomologist, he could yet derive enjoyment from his position as a librarian. Indeed the versatility of his interests is indicated more than once in the records left by his friend. Instance the note regarding his botanical observations.

After discussing in some detail the plants in Andromeda Ponds, Thoreau adds:[18]

[17] "Journal," v. 7, p. 80.

[18] January 24, 1855, "Journal," v. 7, pp. 138–139.

Dr. Harris spoke of this andromeda as a *rare* plant in Cambridge. There was one pond-hole where he had found it, but he believed they had destroyed it now getting out the mud. What can be expected of a town where this is a rare plant? Here is Nature's parlor; here you can talk with her in the *lingua vernacula*, if you can speak it—if you have anything to say—in her little back sitting-room, her withdrawing room, her *keeping* room.

In connection with the publication of the famous treatise by Dr. Harris on "Insects Injurious to Vegetation" we find a characteristic comment. Surely Thoreau must have had his tongue in his cheek when he penned these words:[19]

We accuse savages of worshipping only the bad spirit, or devil, though they may distinguish both a good and bad; but they regard only that one which they fear and worship the devil only. We too are savages in this, doing precisely the same thing. This occurred to me yesterday as I sat in the woods admiring the beauty of the blue butterfly. We are not chiefly interested in birds and insects, for example, as they are ornamental to the earth and cheering to man, but we spare the lives of the former only on condition that they eat more grubs than they do cherries, and the only account of the insects which the State encourages is of the "Insects Injurious to Vegetation." We too admit both a good and bad spirit, but we worship chiefly the bad spirit, whom we fear. We do not think first of the good but of the harm things will do us.

The catechism says that the chief end of man is to glorify God and enjoy him forever, which of course is applicable mainly to God as seen in His works. Yet the only account of its beautiful insects—butterflies, etc.—which God has made and set before us which the State ever thinks of spending any money on is the account of those which are injurious to vegetation! This is the way we glorify God and enjoy Him forever. Come out of the herd and behold a thousand painted butterflies and other beautiful insects which people the air, then go into the libraries and see what kind of prayer and glorification of God is there recorded. Massachusetts has published her report on "Insects Injurious to Vegetation," and our neighbor the "Noxious Insects of New York." We have attended to the evil and said nothing about the good. This is looking a gift horse

[19] May 1, 1859, "Journal," v. 12, pp. 170–171.

in the mouth with a vengeance. Children are attracted by the beauty of butterflies, but their parents and legislators deem it an idle pursuit. The parents remind me of the devil, but the children of God. Though God may have pronounced His work good, we ask, "Is it poisonous?"

There are occasional present-day unlovely exhibitions of professional jealousy, those straws on the stream indicating the character and trend of the current beneath, that tend sometimes to make one wonder if it would not produce a salutary and wholesome effect upon some members of the twentieth century scientific fraternity occasionally to review for purposes of emulation some of these old-time friendships with their freedom from such strains of coarseness. Thoreau, always keenly sensitive to the touch of every form of beauty, has written much of friendship and its loveliness, descriptive of such as existed between Harris and himself. Perhaps some disgruntled individuals might have to stand on tiptoe even to read words like the following about a contemporary,[20] written by the man who might have been "a splendid entomologist if he had not been spoiled by Emerson":

As surely as the sunset of my latest November shall translate me to the ethereal world, and remind me of the ruddy morning of youth; as surely as the last strain of music which falls on my decaying ear shall make age to be forgotten . . . so surely my Friend shall forever be my Friend and reflect a ray of God to me, and time shall foster and adorn and consecrate our Friendship. . . . As I love nature, as I love singing birds, and gleaming stubble, and flowing rivers, and morning and evening, and summer and winter, I love thee, my Friend.

[20] "Week," p. 303.

GEOLOGIC ROMANCE OF THE FINGER LAKES

By Professor HERMAN L. FAIRCHILD
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SUPERLATIVES have been exhausted in praising the Parallel Lakes of New York. They deserve the praise. But the beauty of the lakes and the charm of their setting are not more deserving than is the dramatic story of their making.

In the lakes themselves there is no mystery. The water-bodies merely fill the land depressions to overflowing. The romantic interest lies in the origin and history of the basins which hold the lakes.

A misleading theory in former years, which yet appears in print, claimed that the basins were scooped out by a plowing action of the ice sheet of the Glacial Period. This explanation, which was even applied to the great Ontario basin, was a popular and easy way of avoiding a complex problem in New York physiography. The fact that the bottom of Lake Cayuga is fifty-four feet below ocean level, that of Seneca one hundred and seventy-four feet, and that of Ontario nearly five hundred feet, was the singular and puzzling feature. But the Quebec glacier, which overspread New York and New England and which admittedly had some abrading effect, was not guilty of the valley deepening; although it had some part in producing the basins.

The purpose of this writing is to describe the formation of the Finger Lakes basins—a romance in geology. The physical conditions and the length of time are so far beyond human experience that to appreciate the facts of the story requires of the reader some mental exercise, with constructive imagination. Many people do not like facts, if new, but prefer a world of unreality.

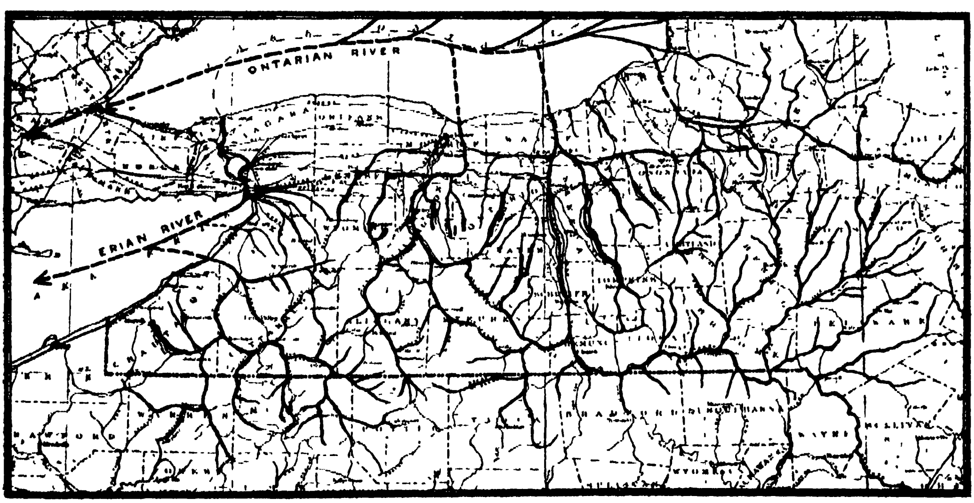


FIG. 1. LATE TERTIARY, OR PREGLACIAL, DRAINAGE OF CENTRAL AND WESTERN NEW YORK

GLACIAL DRIFT HAS SO OBSCURED THE ANCIENT RIVER COURSES, ESPECIALLY OVER A WIDE BELT NEAR LAKE ONTARIO, THAT THE MAPPING IS PARTIALLY HYPOTHETIC

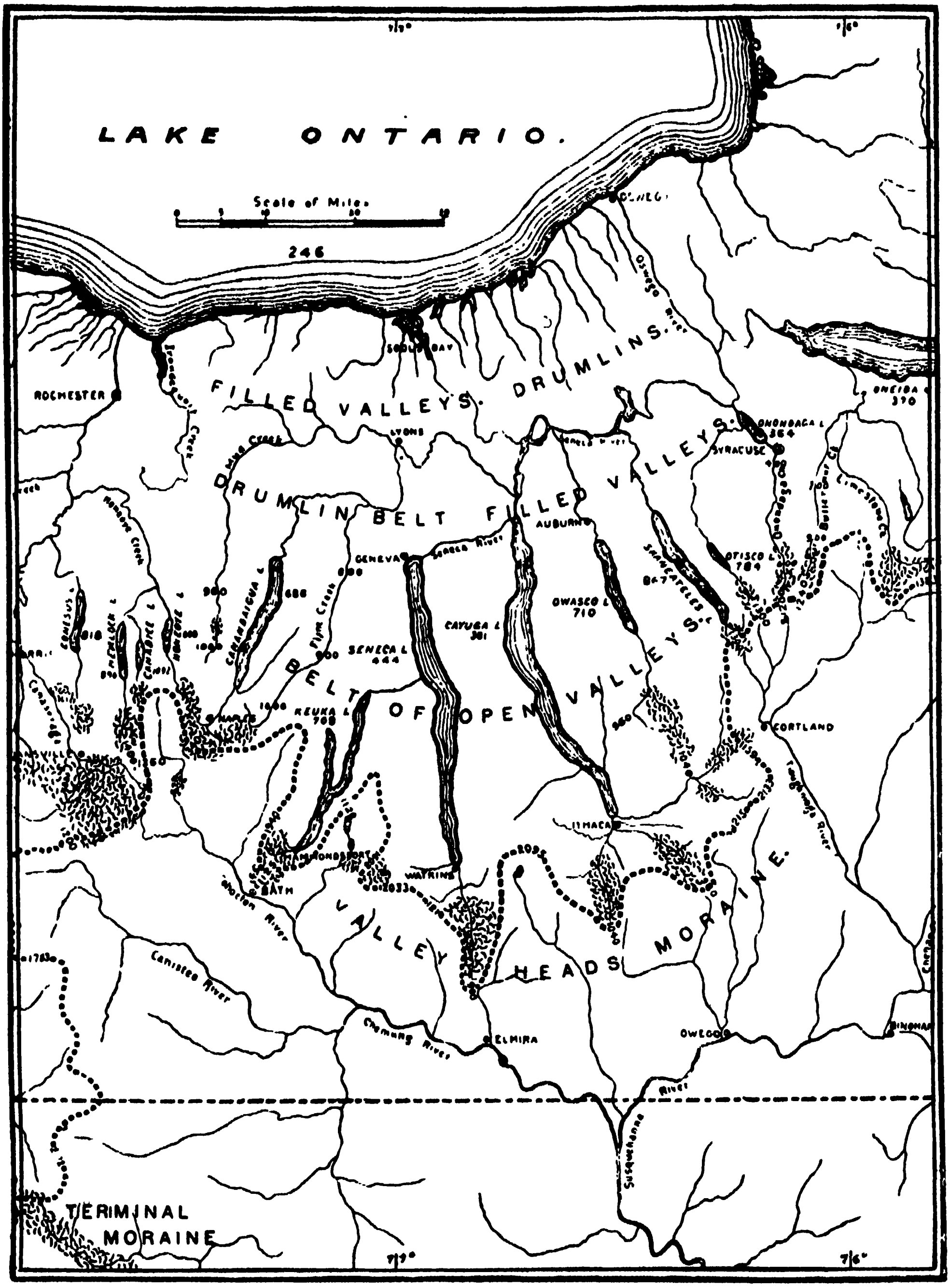


FIG. 2. FINGER LAKES AND PHYSIOGRAPHIC BELTS IN CENTRAL NEW YORK

If the reader happens to be of the latter class he would better break away right here. Yet the story, like many truths of nature, surpasses any fiction of man's invention.

We are so familiar with many lakes,

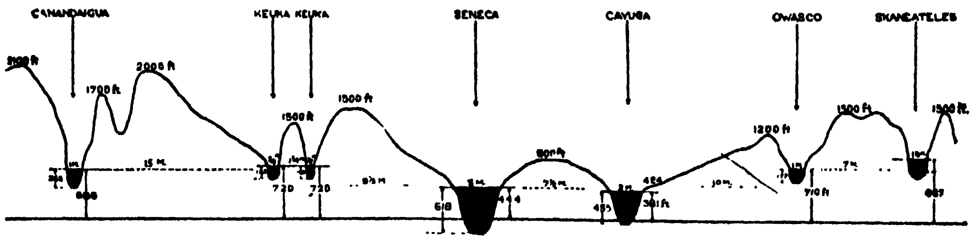


FIG. 3. PROFILE OF LAKE REGION SHOWING DEPTH AND GREATEST WIDTH OF LAKES. BASE LINE IS SEA LEVEL

large and small, that they seem to be normal and permanent features. On the contrary, they are unusual, exceptional and transitory. Excepting the peculiar ones in Florida and on the Mississippi delta there are few lakes to-day in America, outside of glaciated territory. The ox-bows in the flood plains of rivers are not counted.

Most lakes may be defined as expansions of streams. But the basins or

FIG. 4. DETRITAL FILLING AT THE HEAD OF SENECA LAKE

reservoirs are not made by the streams in normal flow. Some external interference or damming effect is necessary. Streams can not permanently dam themselves. Ice-jams, log-jams and landslides make temporary reservoirs. The singular and beautiful lakelets near Syracuse, one in a state park, occupy cataract plunge-basins, and are of very exceptional and interesting character. With their bounding cliffs they are fossil Niagaras. To-day Niagara Falls is drilling a similar bowl. The Syracuse basins were carved by rivers which in function were true predecessors of Niagara. They were held up in forced flow by the front of the waning glacier. Perhaps they are the best example of streams making basins. But these lakelets did not exist while the rivers were flowing.

In regions of land movement, as mountain districts, basins are sometimes produced by the bending and the breaking of the earth's crust. The Jordan Valley and Dead Sea is example of the latter. The basin of Lake Superior is thought to be due in part to crustal warping. But the basins of the Finger Lakes are in practically horizontal strata, lifted out of the sea and without serious deformation.

As reckoned in geologic time, lakes are short-lived. They disappear either by the downcutting of their outlets or by the filling of their basins. Sand and silt are swept in by streams and by winds in arid regions, and vegetable growth assists the filling process. Shal-

Photo by Burwell

LAKE KEUKA

VIEW OF WEST FORK: LOOKING NORTH—CHARACTERISTIC TOPOGRAPHY OF THE FINGER LAKES VALLEYS

low lakes which recently existed in some of the New York valleys have already become plains or swamps. The extensive plains at the heads of the Finger Lakes, Seneca and Cayuga, for example, show the rapid filling by the detritus swept in by the inlet streams.

The scores of thousands of lakes and lakelets in our northern states and Canada came into very recent existence with the melting away of the Canadian ice sheets. Previous to the glacial invasions there were few, if any, lakes in eastern America. This implies that the Finger Lakes are not old. Indeed, they are very young, speaking in geologic lingo. Their life is reckoned only in tens, or at most, in scores of thousands of years. But the valleys in which they lie have been in the making for uncounted millions of years. The Finger Lakes are about the latest geologic features in the state. The cataracts and canyons are younger. Lake Ontario is the youngest great physiographic feature in America.

The origin of the Parallel Valleys must first be learned, and then how they came to be dammed. This series of parallel valleys is probably the most notable in the world. That may sound like American bravado, but the challenge stands. Starting with the upper Tonawanda (Attica) valley on the west, and passing eastward, the other pronounced valleys are: Oatka (Warsaw); Genesee; Conesus; *Hemlock; Canadice; Honeoye;* Mud Creek (Bristol); *Canandaigua;* Flint Creek (Gorham-Orleans); *Keuka; Seneca; Cayuga; Owasco; Skaneateles; Otisco; Onondaga;* Butternut (Jamesville); Limestone (Fayetteville); Chittenango; Cowaselon; *Oneida.* The valleys which now hold lakes are marked by italics. (See figure 1.)

All these valleys drain northward into Lake Ontario. The series might fairly include a number west of the Tonawanda, that swing around into Lake Erie, and others on the east which lead into the Mohawk River. Some of the valleys, as the Oatka, Genesee and Flint, once held lakes that are now represented by plains.

The making of these north-leading valleys is a part of the story which makes demand on the scientific imagination. The history covers the many millions of years since central and western New York were permanently lifted out of the sea. The clear record of the long marine submergence is seen in the rock strata, several thousand feet in thickness, filled with remains of the varied life of the ancient seas. Remnants of the nearly horizontal strata constitute the broad, arching ridges between the valleys, with elevations up to over two thousand feet above sea-level. The valleys are the positive effect, having been carved by atmospheric and stream erosion out of the uplifted land.

When the area of the western part of New York had been permanently raised out of the sea it was a vast plain, declining southward. The Ontario and Mohawk valleys did not exist. All the stream drainage of the area was southward, from Canada across New York into Pennsylvania. A wide belt of comparatively weak rocks lay east and west where the Ontario and Mohawk valleys are now. In that belt the east and west tributaries of the primitive south-flowing rivers had an advantage, on account of the weaker resistance of the underlying rocks. They cut down faster and captured, or "beheaded," the rivers from Canada and developed the east-and-west depression that initiated the Ontario and Mohawk valleys.

Eventually a great trunk river, which we call Ontarian, occupied the depression that is now the Ontario Valley, probably flowing westward to the Mississippi. Of course this great valley had two walls or drainage slopes. On the south wall, sloping northward, the

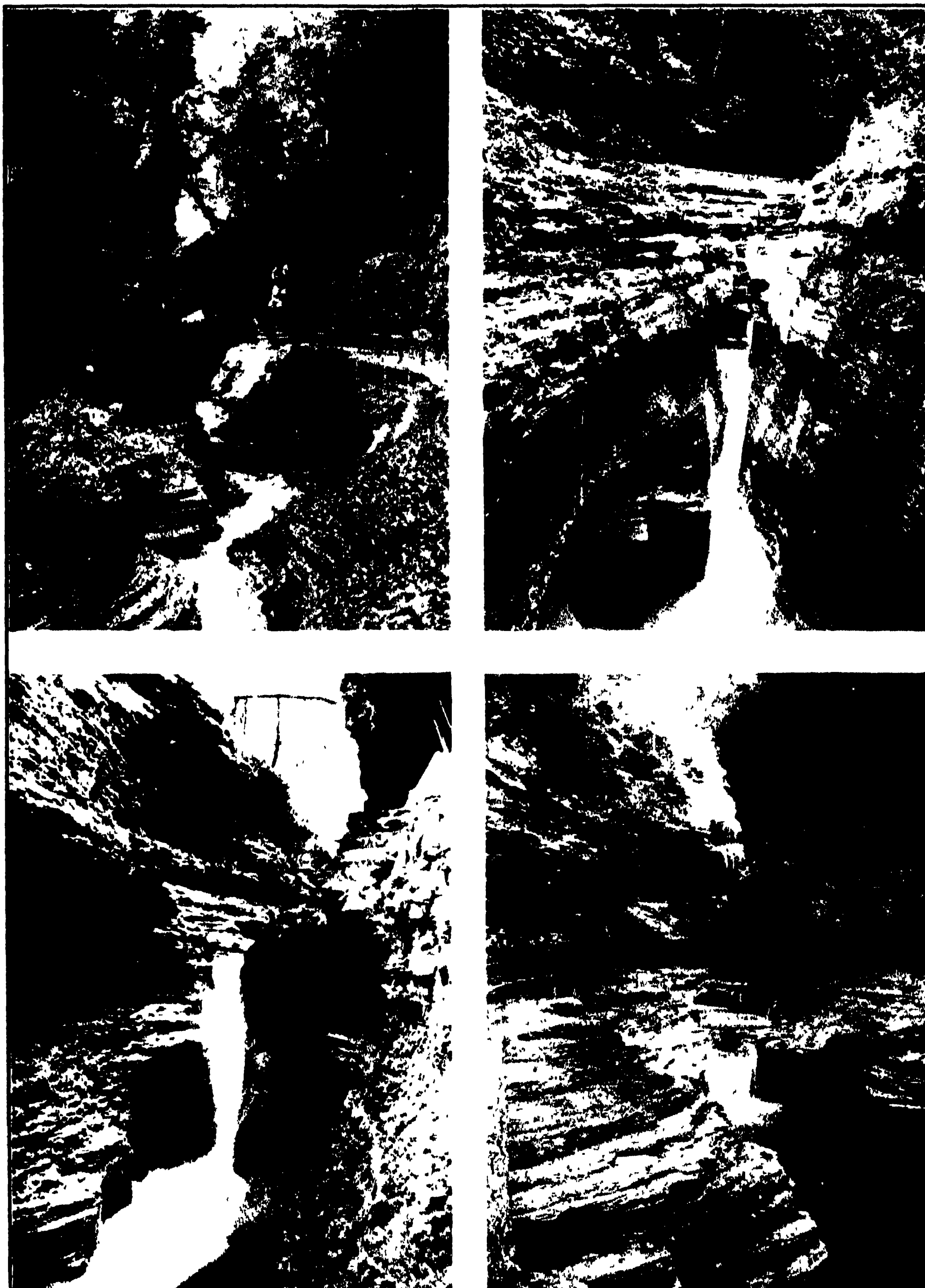


Photo by A. J. Newton

WATKINS GLEN

Photo by C. A. Payne

CAVERN CASCADE: WATKINS GLEN

Photo by C. A. Payne

CHEQUAGA FALLS

IN GLEN OF MONTOUR FALLS, HEAD OF SENECA VALLEY

streams flowed *northward* into the Ontarian River. During the long geologic time, probably part of the Mesozoic Era, or Age of Reptiles, and certainly during the succeeding long Tertiary Period, or Age of Mammals, the Ontario Valley was deepening and widening. Its tributaries from the south were doing the same, and by headward erosion were eating back, southward, into the highland of the southern belt. Eventually these north-flowing rivers deeply intrenched the highland, even into Pennsylvania. Thus all western New York and a belt of northern Pennsylvania was drained north into either the Ontarian or the Erian rivers (See the map, figure 1).

It must be recognized that this northward New York drainage was the reverse in direction of the original, or primitive, flow on the old coastal plain. Of course the Canadian streams retained their southward flow, as seen to-day, until they reached the Ontarian River. The upper Susquehanna and its upper tributaries are probably persistent examples of the primitive southward flow, but they have been beheaded by the Mohawk, flowing eastward.

The parallel valleys of New York were carved in preglacial time by north-flowing rivers; with the possible exception of Canandaigua and Keuka valleys, which appear to have retained, through some distance, the primitive southward flow. But even their streams became tributary to the northward flow (figure 1). If we ever have a geographic survey of the buried rock topography it will doubtless show that the bottoms of the Irondequoit, Seneca and Cayuga valleys are graded to the bottom of Lake Ontario. This will fully account for the depths of the unfilled portions of these valleys.

One surprising element in the reversed drainage, shown in the map, was the capture of the old Susquehanna River. First it was diverted to westward flow, as retained to-day, through Binghamton, Owego and Waverly. But it is believed that it was turned northward at Elmira and did the chief work of deepening the Seneca Valley. We might call this great river the Senecahanna, or the Susqueseneca. Most of the northward drainage in New York appears to have been concentrated in the Genesee and the Susqueseneca.

We now have found the origin of the parallel valleys. Three questions now occur. Why the valleys are cut below sea-level; how they were dammed, to hold lakes; and the cause of the digital arrangement, like fingers on the palm of the hand.

It is difficult for people in quiet portions of the continent to realize that the land is not fixed and eternal. People in earthquake-ridden areas know better. Even continental areas move slowly up and down. During the long eons while the valleys were making, the land of eastern America was probably seesawing, up and down, as it had been doing in earlier time. Just previous to the Glacial Period it probably stood much higher than it is to-day, possibly two or three thousand feet. Certainly the bottom of the Ontario Valley was high enough to allow efficient flow to the sea of the Ontarian River. During the long earlier history of the north-flowing rivers, with lower and more steady position of the land, the valleys were greatly widened. Later, by the Tertiary uplift, the rivers were enlivened or rejuvenated, and they sawed down more rapidly, producing the narrower, and steeper-walled, bottom sections of the valleys.

Rivers are the valley-makers. Mountain or Alpine glaciers modify the valleys which they occupy. They are chiefly agents of transportation. Their minor work of erosion tends to widen rather than deepen their channels. They change stream, or V-shaped valleys, into U-shaped. But the ice work in New York was not that of stream glaciers but that of a widespread or continental ice-sheet. It had little power of deepening valleys, but was effective rather in filling and

Photo by Ithaca Eng. Co.

ITHACA FALLS
BELOW THE CAMPUS OF CORNELL UNIVERSITY

damming the valleys. Lobations of the ice margin pushed into the old valleys, during both the oncoming and the recession of the glacier. But the lobes, pushing up the valleys, with imprisoned lakes facing them, were heavily loaded with rock-rubbish (glacial drift), and had little power of erosion. Moreover, the bottom ice in the deep valleys is believed to have been comparatively stagnant, serving as the bridge for the flow of the plastic upper ice. When the ice-sheet was thick it moved southwestward, or diagonally across the central valleys. And, as noted above, the later lobations were too heavily loaded with bottom drift to do effective cutting. They piled their drift burden mostly in the hummocky deposits that now make the divides or water-parting south of the lakes (see figure 2).

In general the ice-sheet had only a smoothing or sandpapering effect on the land surfaces. It rubbed down the projections and filled the depressions, thus producing the remarkably uniform curving surfaces which give the slopes of the Finger Lakes valleys their graceful outlines.

During the later stand of the Quebec ice-sheet it completely filled the northern ends of the valleys with its drift deposit, forming the wide plains north of the lakes. This drift filling makes the dams that hold the lakes.

In addition to this northern blocking of the valleys another agency has helped to make the basins. This is the tilting uplift of the land. The weight of the Quebec ice-cap, many thousand feet thick, depressed the land. When the ice was removed the land rose, slantingly in New York. The amount of slant, or uptilting, has raised the north ends of Cayuga and Seneca lakes about eighty feet more than the south ends. As the outlets are at the north ends it is evident that the land movement is partly responsible for the lake basins.

However, the "basin" character has been overemphasized. A true vertical profile of the basins shows that they are comparatively shallow. If the depth of Lake Seneca (618 feet) be represented on a diagram by one inch, then the length of the lake (thirty-six miles) would be twenty-six feet. On the same scale the length of Cayuga would be forty feet. And if the depth of Ontario be diagrammed as one foot, the length of the lake would be nearly one fourth of a mile. Evidently, no appeal is necessary to a fanciful deepening by "glacial erosion."

The singular direction of the central valleys, converging northward, is an effect of the stream flow being directed by the general slope of the broader land surfaces; and the latter being determined by the character of the rocks in which the valleys were carved. As stated above, the east and west Ontario-Mohawk depression was initiated on the outcropping belt of weak strata, and it became the master valley because of the great thickness of these non-resistant strata. In New York these weak strata are thickest on the meridian of Seneca and Cayuga lakes, where in the vertical series of five thousand one hundred and fifty feet of strata, between the Trenton limestone below and the Portage sandstone above, four thousand five hundred feet are weak shales, three hundred and fifty feet soluble limestone and only two hundred and fifty feet sandstone. Consequently the south wall of the great Ontario Valley in the district of the Cayuga and Seneca tributaries receded rapidly, producing the decided concavity as shown by the south shore of the present lake. Naturally the northward stream-flow was directed by the prevailing land slopes and converged toward the district of more rapid erosion.

The complex history of the Finger Lakes may be summarized as follows:

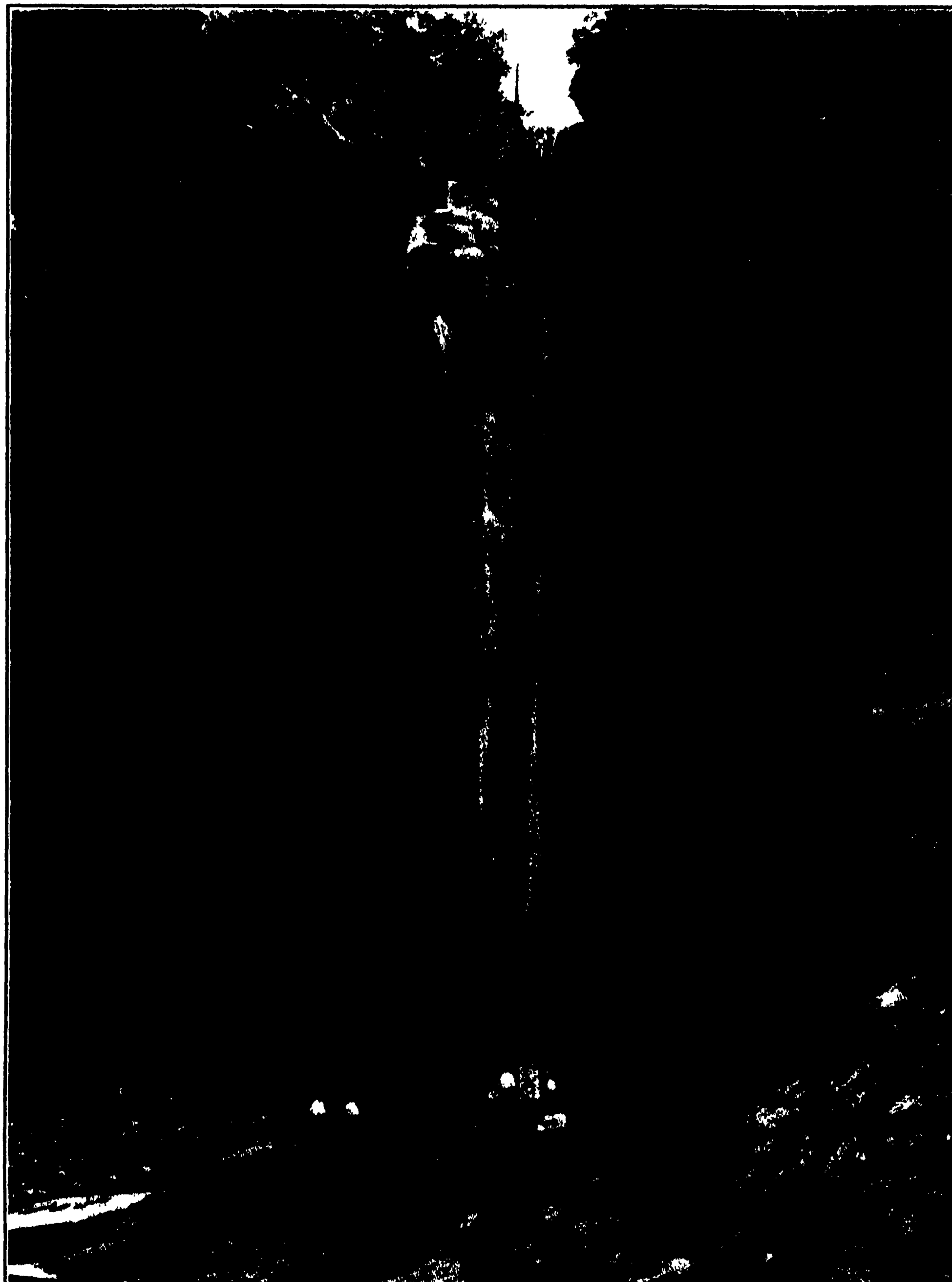


Photo by Ithaca Eng. Co.

TAUGHANNOCK FALLS

EAST SIDE OF CAYUGA VALLEY, NINE MILES NORTH OF ITHACA. THE HIGHEST CATARACT IN THE EASTERN UNITED STATES

(1) The original drainage on the uplifted sea-bottom, or coastal plain, was southward across New York from Canada. Only a few remnants of that primitive flow now exist in western New York, with the upper Susquehanna and its tributaries in the eastern district.

(2) Evolution of the great east-and-west Ontario Valley, in a wide belt of weak rocks, shales and limestone, by the Ontarian River, beheaded the Canadian rivers.

(3) Northward tributaries of the Ontarian River, on the south side of the expanding valley, ate back (southward), by head-waters erosion, into the Allegany Plateau, even to Pennsylvania. In this way was developed the remarkable series of parallel valleys; the reverse, in direction, of the original drainage (figure 1).

(4) High elevation of eastern America, in later Tertiary time, enlivened the rivers by increasing their fall to the sea, and hence their velocity. This caused rapid down cutting of the valleys (figure 3), so producing the steeper lower walls of the central lakes, and the convexity of the slopes.

(5) The high elevation of eastern America, possibly accompanied by a slight lowering of world climate, produced vast and deep ice sheets. The latest one, the Quebec glacier, overspread New York, and subdued the state to the same condition that Greenland now suffers.

(6) In the waning of the Quebec glacier and the recession (northward) of its south front, it served as a barrier in all of the north-sloping valleys. Glacial lakes were thus held in all the valleys, and the present lakes are lineal descendants of the ice bound lakes.

(7) During pauses in the recession of the ice front the heavy load of rock rubbish was piled in the valleys. One great series of these frontal moraines is the heavy fillings south of the lakes. Another forms the wide plain that buries the north ends of the valleys, and produces the lake basins. (See figure 2.)

(8) Northward uptilting of the land since the weight of the ice-cap has been removed has lifted the north ends of the lakes, thus producing some increase in their depth.

(9) The filling process, by inwash of detritus and the accumulation of peat, has already obliterated some of the shallower lakes, and has made a beginning on the destruction of the remaining lakes. Witness the extensive plains at the heads of Canandaigua, Seneca, Cayuga and Owasco Lakes (figure 4).

RADIO TALKS ON SCIENCE[1]

THE PLANET MARS IN 1926

By JAMES STOKLEY

SCIENCE SERVICE, WASHINGTON, D. C.

On the twenty-second of August, two years ago, the country was very much excited about Mars. The ruddy planet shone brilliantly in the night sky, for it was only thirty-four million miles away, closer than it had been for many years or would be for many years to come. Much that was said about it was sound, scientific fact, but there was also much that was not so scientific; as, for instance, the discussion as to the possibility of the Martians, if there are any, communicating with us by radio!

But the astronomers, quietly working in the observatories, were not interested in these speculations, for they were too busy watching the planet through their telescopes, photographing it, measuring its heat and performing a host of other processes with the distant planet as their subject. Perhaps there is life on Mars or on some of the other planets, but the astronomer, as such, is not concerned in knowing whether there is or not. He can measure the light of the planet or its color, but the question of whether or not there are intelligent beings there is beyond the reach of his instruments, and so he does not bother about it.

Mars, this summer, will be a brilliant object in the morning sky. By autumn, it will be visible in the eastern sky late in the evening, until November 4, when it will be directly south at midnight and visible throughout the night, its brilliant red color leaving no doubt as to its identity. To those who watched Mars in the summer of 1924, it now comes as an old friend returning after many wanderings. On the 27th of October, 1926, when it will be closest, it will have more than completed an entire circuit of its orbit, traveling more than a billion miles, since the night of August 22nd, 1924. In the same time, the earth will have traveled more than a billion and a quarter miles in its orbit.

Last September, when Mars was on the side of the sun directly opposite the earth, the two planets were farthest apart—over 230,000,000 miles separating us from each other. But now, Mars is again coming close, and on the 27th of October it will be but 42,624,200 miles from us, farther than in 1924, but better for astronomical observation, despite the additional distance, because of the way the earth's atmosphere lets its light in to us.

On account of the atmospheric blanket which surrounds the earth, we can see a star better when it is directly overhead. When it is down near the horizon, its light passes through a much greater thickness of air, and much of the light is absorbed, a fact apparent to any one who has seen the sun just before setting.

Stars, and planets likewise, appear fainter and more unsteady when they are near the horizon. This summer Mars will be considerably higher in the sky for observers in northern countries than it was in 1924; and as most of the world's observatories are located north of the equator, the planet will be better

[1] Broadcast from Station WCAP, Washington, D. C., under the auspices of the National Research Council and Science Service and the direction of W. E. Tisdale.

situated for observation, despite its greater distance—about 25 per cent. greater than in 1924. Already the great telescopes have been trained on it, and perhaps the coming months will add as much to our knowledge of the planet as did the summer of 1924.

Of most popular interest when we speak of Mars are the so-called "canals." Discovered in 1877 by the Italian astronomer Schiaparelli, they have since been a bone of contention among astronomers. One group has supported the views of the Italian, while another has doubted their very existence, claiming that those who thought they saw them were the victims of an optical illusion.

But in 1924 better instruments than ever before were trained on the planet and the canals were reobserved by astronomers who had seen them before. Others who had previously been skeptical saw them for the first time. At the great Lick Observatory of the University of California, situated on Mt. Hamilton, near San Jose, California, Professor R. J. Trumpler watched the planet with the thirty-six inch telescope and was well rewarded for his pains. He made many drawings of the canals and what he saw was verified by Professor W. H. Pickering, at the branch station of the Harvard College Observatory at Mandeville, Jamaica, who was also making drawings of the planet at the same time. Both observers, though thousands of miles away, saw the same things!

However, a photograph is often accepted in a court of law as the best possible evidence, and when one sees a photograph of the "canals," it would seem that there is no further question of their existence. But good photographs of Mars, even with the finest instruments, are not easily made. While the photographic plate has replaced the human eye to a great degree in most branches of astronomy, observations of the planets are still best performed visually, and the best photograph of Mars that has ever been made shows but a small fraction of the detail that can be perceived by a trained observer, when looking through a powerful telescope.

One reason for this is the red color of the planet. Of all colors, red has the least effect on the ordinary photographic plate; hence a red light is used in the dark room, and when a photograph is made of Mars, the exposure must be very much longer than if the planet were blue, for example. While the exposure is being made the planet moves slightly, but this does not produce as serious an effect as the atmosphere of the earth. Continually in motion, the layers of different temperature in the air bend the rays of light from the planet first one way, then another, so that sometimes the edge of the object is sharp and distinct, and the next moment it seems to "boil."

When an experienced observer looks at such an object, the occasional glimpses that he gets when the "seeing" is good, suffice to give him an accurate idea of the general appearance. The plate, however, can not select the most favorable moments, but must take the combined appearance over a period of at least several seconds.

Despite these difficulties, photographs have been made which reveal the markings, called canals, and in fact, they had been made before 1924. In 1916, when Mars was almost as close, Mr. E. C. Slipher, at the Lowell Observatory at Flagstaff, Arizona, succeeded in recording them on the sensitive emulsion of the photographic plate. In 1924 he made still others, and Dr. Trumpler, at the Lick Observatory, also made pictures which reveal them, so it is unlikely that any astronomer will suggest in the future that the canals are optical illusions. This does not necessarily prove them to be artificial, and the general idea is that they are due to some unknown, but natural cause.

Photographs by light waves vibrating too fast or too slow to be perceptible to the eye gave valuable information to the astronomers when Mars paid its last visit. The earth's atmosphere reflects violet and the invisible ultra-violet light, but transmits the red and infra-red. Dr. W. H. Wright, of the Lick Observatory, took his camera and made photographs of the town of San Jose, which can be seen from the mountain. He used special filters and plates and made pictures by ultra-violet as well as infra-red light. Although the day was not especially hazy, in the ultra-violet pictures the town is completely obscured by what appears to be a dense fog; while those made by infra-red rays show the details of the town as though but a few feet distant.

Then Dr. Wright used the same filters and plates in the telescope to photograph Mars, and there also he found that planetary markings which were distinct with the red were entirely obliterated when the violet was used. As this was at night, when the earth's atmosphere was not illuminated, the effect was therefore almost certainly due to an atmosphere on Mars, similar to ours. But even more striking was the effect obtained when half of an infra-red picture was joined to half of one by ultra-violet light. Instead of matching, the ultra-violet image was considerably larger! This, then, was the Martian atmosphere, and by measuring the diameter of the planet in the two pictures the actual height of the layer of air on our neighbor was determined.

But even if the air is there, it might not be of quite the same composition as ours, nor need it be as dense. Indeed, observations made in 1924 at the Mt. Wilson Observatory, by Dr. Walter S. Adams and Dr. Charles E. St. John, have definitely established, they claim, that the water vapor and oxygen content in Mars' atmosphere represents only a small percentage of that found in the earth's atmosphere and is probably even rarer than that at the summit of Mt. Everest.

"The quantity of water vapor in the Martian atmosphere at the time of observation," says Dr. Adams, "was 6 per cent. of that over Mt. Wilson, or 3 per cent. of that over Pasadena. These results would indicate desert conditions over at least the greater portion of Mars. Measurements of the quantity of oxygen indicate a presence of 16 per cent. of that over an equal area of the earth's surface."

There remains one other factor that makes life possible, and that is temperature, so it is not surprising that efforts have been made to find out what the thermometer would read on Mars, if there were a thermometer there and some one to read it! Dr. W. W. Coblentz, of the Bureau of Standards, did this at the Lowell Observatory with Dr. C. O. Lampland. Using a very delicate instrument, known as the thermocouple radiometer, attached to the forty-inch reflecting telescope, he was able not only to measure the average temperature of the planet, but even to select certain areas and find out whether or not Martians in a certain section of the planet were suffering from a heat wave!

"These measurements show," according to Dr. Coblentz, "that the bright regions are cooler than the dark regions; that the sunrise side of the planet is at a lower temperature than the side under the afternoon sun; and that the polar regions are cold, emitting no planetary radiation, and having temperatures down to perhaps 90 degrees below zero Fahrenheit. The temperature of the dark part of the sunrise side of the planet is very low, probably down to 75 degrees below zero, Fahrenheit. The average of the measurements indicate that the temperature of the brightly illuminated surface of Mars is not unlike that of a cool, bright day on this earth,

with temperatures ranging from 40 to 60 degrees Fahrenheit."

Mars, then, does not seem to have conditions greatly different from those of parts of the earth. It is somewhat cooler, as it is fifty million miles farther from the sun than we are, more than half again as far from the source of energy of all the planets, but does that preclude the possibility of life there? When we consider the great variety of conditions that man is capable of surviving and the still greater variety that other forms of life can stand, it does not require any wild feat of the imagination to picture there some living organism, possibly much more primitive and quite different from any that we know. But the astronomers do not concern themselves with these imaginings. They are speculations, and the silent men in the observatories still continue to seek the facts that may come out of their researches.

HOW PLANTS BEHAVE WHEN DISEASED

By Professor B. M. DUGGAR

WASHINGTON UNIVERSITY AND MISSOURI BOTANICAL GARDEN

To you of the radio audience who may already know much about the diseases of plants I must apologize for selecting so broad a subject, for this is primarily addressed to those who have watched plant behavior less closely. We begin with the thesis that plants always behave, that is, they react, to sunshine and darkness, to drought and rain, to the food substances that may be supplied by way of the soil, and in far more diverse ways they react to the germs and other agents of disease that beset them on every hand.

The amateur flower lover, who watches every plant and bloom, knows the significance of blight and mildew, and the commercial grower of grain or fruit must nowadays be something of a specialist in rusts and leaf spots. And why? It is because the sum of the losses throughout the country, from such maladies, reaches a staggering figure, perhaps nearly a billion dollars annually, to say nothing of the agony of spirit which is the only loss registered by the amateur. There have been years when in the United States alone the grain rusts caused a loss estimated at $67,000,000. The potato blight has taken a toll of around $40,000,000 annually.

If there were for plants as a whole so few diseases as there are for human beings it would be a far simpler matter to learn about them, but practically every cultivated plant has its own particular round of diseases—its measles, diphtheria, scarlet fever and smallpox, we might say; but actually we have very distinctive names based upon the behavior of the plant affected. For example, there is the mildew of rose, the leaf curl and the brown rot of peaches, the blight of apples and pears, the tip burn of potato, the crown gall of grape, the witches broom of cherry, the white leaf spot of violets, the black knot of plum, the mosaic of tobacco, the smut of corn, and literally thousands of others too numerous to distinguish by popular terms alone.

Now these terms—rot, spot and what not—indicate how the plant is behaving, and always there is loss of production of flowers or fruits or whatever may be the harvest. When the peach leaves "curl," they later fall and there is no crop. When the rose shoots mildew, the

blossoms are imperfect. Even if the damage is relatively slight, who wants to buy scabby apples or blighted tulips?

Not only are the effects of plant disease so diverse, but the progress of disease in any particular case may be very rapid or very slow. Down through the Shenandoah Valley recently there was celebrated a great apple flower fête. In all that region the bees are busy gathering honey and incidentally pollinating those flowers. But if the fruit growers were not diligent, and if there were here and there in the orchards blighted trees of pear or apple which might be visited by the bees, the germs of blight would be spread far and wide. In a few weeks the dreaded fire blight would, as it were, sweep through the orchards, with a loss almost as great as from frost. This is an example of quick effect.

On the other hand, out there in the woods is a beech tree with a wind-broken stub of a branch. The stub dies and the fine mould like strands of a fungus grow into the wood of the stub, later into the living tree and gradually year after year the wood within decays. There comes a storm, and such a tree has lost its resistance; it falls easily before the wind. Then, if not before, we discover the cause, and see that the insidious agent of disease is as slow and yet as sure as cancer.

When I spoke a moment ago of the blight of apple and pear, we were dealing with a disease caused by a germ in the truest sense of the word. The organism causing this disease belongs to the same family of little germs as that causing tuberculosis of man, the bacteria. It is one of a great number of plant diseases due to different species of bacteria, and bacteria, you know, are very simple in form and microscopic in size.

The majority of plant diseases are caused by organisms that bear the name fungi, but not all fungi are disease producers. There are a few fungi familiar in the home, such as the bread or cheese moulds. From the standpoint of the complexity of living things these fungi are a little more respectable than bacteria. In many cases we can see the growth readily, even the vegetative growth, and in general this vegetative stage is in reality a vast entanglement of little threads. The disseminating bodies are minute spores.

Perhaps we can best illustrate these causes of disease by considering another case, and since the apple has been under discussion I will take the *apple rust* as an example—and, I must admit, a very curious example. The disease is almost uncanny in its behavior. At this season of the year it is not to be found on the apple at all but on the cedar instead.

If you go out into the woods now where cedars and crab apples abound, you will find on the little branches of the cedars certain galls as large as walnuts—cedar apples they are called. After a rain, a little later in the season, these galls will exude great orange-colored horns, bearing millions of spores that will spread this disease to apples, as we shall see, in the orchards about. In other words, these cedar apples are just a peculiar growth of the cedar twig when infested with and permeated by this fungus. The spores from these cedar apples fall upon the young apple leaves, and there they grow into the living tissues. When summer comes, such affected leaves will show conspicuous orange spots, indicating a vigorous development of the fungus within. Both leaves and fruit may be affected and the damage in premature leaf drop and in fruit injury may be great. But before the leaves fall another type of spore is produced, and this must be carried by wind or rain back to the cedar, where another infection and growth of galls will occur. It is clear that when we know the life histories of these diseases—

or whence they come and where they go, and the time of it all—we shall know how and when to strike with preventive or remedial agents.

So far we have been speaking of bacterial and fungus diseases. We might almost say that we have tamed most of those. But there is another class of diseases phenomenal in every way. These are the so-called mosaic diseases. They are generally highly contagious, and any one can pick out the diseased plants yards away by the yellow and green, blotched appearance. The plants do not die, but they do not produce efficiently. There are such diseases of tobacco, tomato and potato, sugar cane and corn, bean and cucumber, columbine and Poinsettia. The potato with such a disease is often said to be running out or deteriorating, tomatoes produce only during the first part of the season, and the columbine fails to flower.

The remarkable thing is that the causes of these diseases are agencies so small or so peculiar that in no case have they been recognized with certainty under the microscope. We think it is beyond the power of the microscope to recognize them, that is, they are ultramicroscopic. This seems to place such causes of disease among what have been called virus diseases, of which there are several conspicuous examples among man and higher animals, such as smallpox, measles, rabies and others.

In the case of the mosaic of tobacco, for example, we know that the virus is transferable by insects which feed on the plant juices by pricking tiny holes in the leaves or stems. We know about the behavior of such a virus outside of the plant, because we can extract the juices of infected plants and then inoculate them into healthy plants and thus determine whether the virus is still active or not. But there is a solemn mystery about the thing, just as there is about force, about electricity. Imagine working with a disease germ that you are not able to visualize or perceive in any way except by seeing the behavior of a plant that is inoculated with it. We think that if we can solve the riddle of such virus diseases of plants we may be able to cast a flood of light upon the virus diseases of the human being.

Of course, we could eradicate apple rust in any region by destroying the cedar or eliminating the cedar galls. We control quite satisfactorily, by spraying, the more widely distributed diseases of the grape, of the apple, of the potato and of many other staple crops, and there has sprung up around this system of control an enormous industry in fungicides and fungicide machinery. We can not readily and practically control by spray methods the rusts of grain, peach yellows, the wilt of cotton, the various mosaic diseases and hosts of others. Look back a few years when our eastern woods were stocked with chestnuts. These are all gone or going, and a single disease, the chestnut blight, is the cause. Gradually, however, through the development of the research work that is being conducted in plant breeding and genetics we are realizing that varieties resistant to diseases may be found or may be produced in a large number of cases and that our ultimate conquest of such diseases must be through the propagation of resistant plants. In all the great domain of plant diseases there is no single case of immunity in the sense that a plant once diseased will become immune to further attacks of the same disease. The problem of acquired immunity so well defined in man and animals is then unknown in the plant kingdom. We may expect, therefore, that the same tree or bush or plant will be affected year after year if the disease germs reach it and if the weather conditions are favorable for the development of the malady.

Few persons outside of those actually in contact with the work realize, I dare say, the extent of the organization now in existence, functioning, as far as possible, to get new light on plant disease and to keep disease away from crops. In the U. S. Department of Agriculture, in the various state agricultural colleges and experiment stations and in many endowed educational institutions throughout the country, there are considerably more than a thousand trained scientific men devoting their time and energies to this work. That, remember, is merely the scientific side of it.

Fifty years ago there was in this country but a single student of plant diseases, Farlow, at Cambridge. A few years later Burrill, at the University of Illinois, recognized and described the first bacterial disease of plants. Shortly thereafter the Department of Agriculture and several other experiment stations entered the field, and now the organization for plant disease study in the United States is first in the world.

Perhaps it is true that the prevalence of fungus diseases in the United States has been the animating factor in our superb organization for research. We should bear in mind, however, that with all our present knowledge of plant diseases the problem of control will always remain, just as with human diseases. Some few diseases may be eradicated, and the vast majority may be satisfactorily—though often at considerable cost—controlled, but still others have baffled the best-laid plans of the pathologist.

THE PECULIARITIES OF THE SENSATION OF COLD

By Professor D. FRASER HARRIS

EAST GRINSTEAD, SUSSEX, ENGLAND

It may seem a curious thing to say that, although there is no such thing as cold in the sense that there is heat, yet we have in the body nerves for the sensation of cold. Let us try to make this mystery plain.

According to the present views of physicists, cold has no objective or "real" existence: whereas there *is* such a thing as heat and we can measure it. There are, moreover, nerves for the perception of heat.

Although there is no objective cold, there are nerves for perceiving cold.

Heat can be made to enter or leave a body; but as there is no such thing as cold apart from sensations, cold can not enter or leave a body.

Just as there is light and a nerve of vision wherewith to see light, so there is heat and there are nerves for the sensation of heat; but since there is no objective, external cold, it is remarkable that there should be nerves for the purpose of perceiving cold.

Heat is a more or less violent disturbance of the molecules of matter—gas, liquid or solid—and it can be transferred from one mass of matter to another. A change of temperature is the sign that heat is being transferred from the hotter to the colder body.

When two bodies are at the same temperature, there is no transference of heat between them.

Temperature is to heat what a head of pressure is to water in movement.

If we plunge a hot poker into cold water, the poker will lose heat and fall in temperature, the water will gain heat and rise in temperature.

The human body can absorb heat from the sun, fires, hot baths, etc., and we have the sensation of warmth in consequence: here heat is coming into the body. But the body is always producing heat, and heat therefore is always leaving the body; for if it did not, but accumulated continuously, the heat would in a few days cremate the living body.

If there is plenty of warm blood in the skin we feel warm as when we flush or blush; although heat is *leaving* the body; and conversely, when there is little blood in the skin, as in blanching and an ague-fit, we feel cold.

Some heat is leaving the body all the time; and yet we are not cold all the time: so long as there is a moderate amount of blood in the skin we feel comfortable and neither too hot nor too cold.

When under any circumstances the animal heat is carried off very rapidly, as into air when we rush through it in a motor car or to water as in a cold bath or to a solid when we sit on a cold stone seat, then we say, "it" is cold, we "feel" cold, we "are" cold, although there is no real cold in the outer world.

It is, therefore, not only the loss of heat but the rate of that loss which determines how cold we feel.

Thus when we place our hands in ice-cold water, we say it is much colder than ordinary drinking water only because in the former case heat is leaving the skin at a much faster rate than in the latter. It is a question of the *rate* of the transference of heat through the skin, and of the amount of blood in the skin at the time; for when there is plenty of blood

in the skin, as in blushing, we say we feel warm, although heat is leaving the body; but when there is not much blood in the skin and heat is still leaving it as in ague, we say we feel cold.

In any case, when we feel cold there is no such thing as external cold coming into our bodies from outside; on this both physicists and physiologists are agreed.

Let us consider one more case; suppose we close our eyes, and place the hand in oil at exactly the temperature of the body, we shall feel the hand neither hot nor cold, and we may not be aware of the presence of the oil at all. It must be quite a familiar experience that if we happen to cut a finger painlessly and without noticing the flow of blood, we do not feel the blood at all, and only know we have cut our finger by happening to see the blood somewhere. Blood at exactly the temperature of the body is not felt; as regards the body it is neither hot nor cold, and this state of physiological Laodiceanism is not perceptible. We seem, then, to be able to distinguish four cases:

(1) When heat comes in through the skin, we feel hot;

(2) When heat goes out through the skin, we sometimes feel cold;

(3) When heat goes out through the skin, at other times we feel hot. And (4) when heat neither comes in nor goes out, we have no thermal sensations at all.

Our sensations of heat or cold (thermesthesia) would seem to depend on the transference of heat and not on its direction across the skin.

The amount of blood in the skin is a powerful factor determining our sensations as to cold and therefore our opinion as regards the comfort, for instance, of a room. Thus, suppose a person has been sitting in a room without a fire doing hard mental work or having an ague-fit, he will be "cold all over"; even if his head is warm, his feet are cold; he is quite uncomfortable and says the room is cold and needs a fire. Just as he is about to light it, some one may come in from a brisk walk all aglow with plenty of blood in the skin who will at once pronounce the room quite warm and not in the least in need of a fire: it is a question of relativity. But the temperature of the room is exactly the same for both men.

The presence of blood in the skin will make a person feel warm, for a time at least, whatever be the thermal state of his environment, even although heat is continuously leaving the body.

Let us now carry out a very simple experiment: suppose we place in a basin of water at room temperature one finger previously chilled by ice-water, and another previously warmed by hot; then the water will appear hot to the cold finger and cold to the warm finger. Yet of course the water can only be all of one temperature: the sensations are called contrast effects; but they are another case of relativity. Evidently the state of adjustment on the part of the nerves of the skin towards the passage of heat across them must be a factor determining whether we feel hot or cold.

That state of the skin in which we feel an object neither hot nor cold is called its "adaptation temperature" or its "physiological zero."

We can be still more explicit and say the physiological zero is of such a kind that if the temperature of the environment rises above it the sensation is of heat, but if below it, the sensation is of cold.

Lastly, do we possess nerves for perceiving cold as distinct from those for heat? It is believed we do. The whole of the evidence can not be given here; but some of it may be learned from a careful exploration of the skin carried out by a simple instrument.

The instrument is merely a rod of metal, *e.g.*, copper (about the diameter of a lead pencil), cut to a not too fine point. If this rod be repeatedly pressed

lightly on the skin, point by point, and the blindfolded person asked to report his sensation at each time of contact, then the possible reports are: "touched"; "hot"; "cold"; "doubtful"; "nothing."

By "doubtful," the person means he is not quite sure whether the spot touched feels hot or cold or has merely had a contact: by "nothing" he means that although he *knows* he is being touched by the rod, the sensation is neither hot nor cold but is so vague that he is not positive about the contact. As a matter of fact, the rod is over a pain-spot, but the pain will not be elicited until the pressure becomes greater. Hitherto the rod is supposed to be at room temperature. If now we chill the rod in ice-cold water and apply it as before, the reports are—"contact"; "distinctly cold." In this case the moment a "cold spot" is touched, the sensation is very obviously cold; but the heat-nerves are not stimulated. If the rod be at the temperature of the skin, then only contacts are reported. If an area of skin be selected, say, on the back of the hand and the contact, the hot and the cold spots are marked out each with a different color, then it can be seen that the pattern for each nerve is different from the others.

There are more cold spots than hot spots per unit area of skin.

As regards internal organs, their endowment for perceiving heat and cold is very imperfect: we can swallow liquids painfully hot or cold to the lips and scarcely perceive them when once they have reached the stomach.

The general inference from all this is that the peripheral endings of the nerves for the sensation of cold are distributed in the skin in a punctate manner; and that they are stimulated moderately by a rod at room temperature and much more vigorously by one thoroughly chilled.

Further we may infer that the distribution of the cold-perceiving nerves is different from that of the hot nerves and also from the contact nerves. We have evidence that the impulses coming in on the hot and cold nerves travel up in a part of the spinal cord which is distinct from those tracts in which impulses of touch and of the muscular sense travel. Thus it is that a person who has sustained a particular kind of injury to the spinal cord has no sensations of heat or cold or pain so that he can pick up a red-hot coal or an excessively cold piece of metal and feel no pain.

The cold-perceiving nerves can be stimulated chemically, as, for instance, by menthol. If you rub some pure menthol on the skin of the forehead, then for some time afterwards everything will seem very cold. Touching the skin with a finger, even blowing over it, far less placing a bit of ice on it, will all be interpreted as very cold.

Thus we have learned that although there is no such thing in the universe as objective ("real") cold in the sense that there is heat, yet we have a system of nerves in the body with endings in the skin whose office it is to perceive cold as distinct from heat.

The more we know of how our bodies are constructed and endowed, the more we must wonder at the details of their capabilities and adaptations, even although we do not always fully apprehend their meaning.

DR. JOHN HOWLAND

PROFESSOR OF PEDIATRICS IN THE JOHNS HOPKINS UNIVERSITY, WHOSE RECENT DEATH IN LONDON IS A SERIOUS LOSS TO MEDICINE AND TO SCIENCE. THE PHOTOGRAPH, WHICH WAS TAKEN IN 1920, SHOWS PROFESSOR HOWLAND WITH HIS STAFF IN THE JOHNS HOPKINS HOSPITAL.

THE PROGRESS OF SCIENCE

By Dr. Edwin E. Slosson
Director of Science Service, Washington

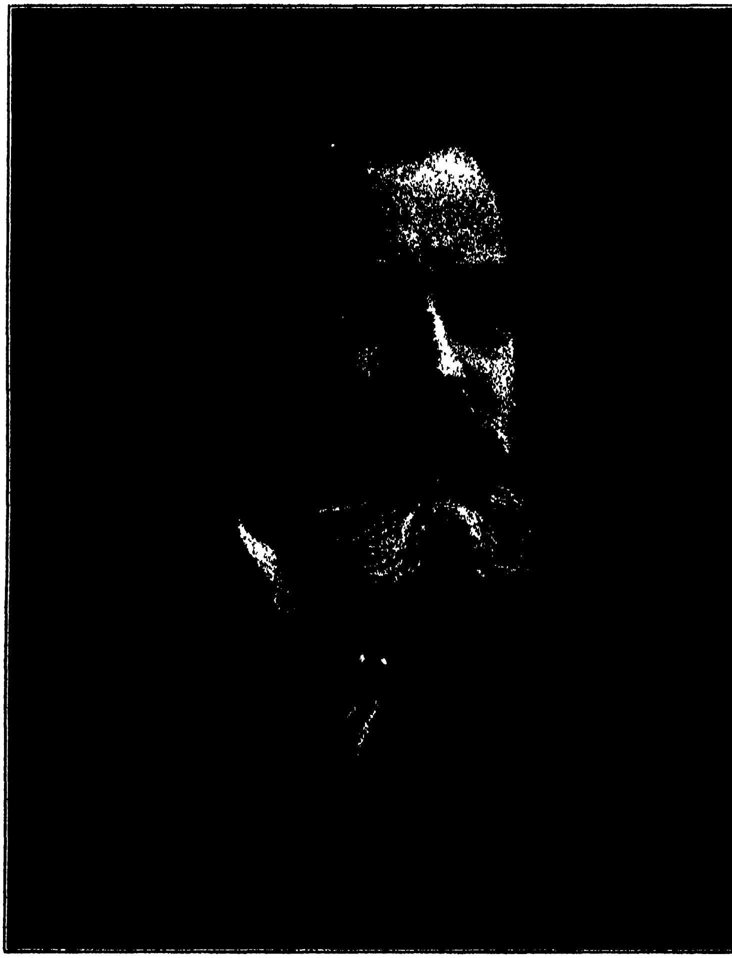
ELECTRIC FARMING

One of the funniest things I saw in Sweden when I was over there recently was the use of electrical cookstoves in forest cottages. Sweden is short on coal and oil, but long on wood and water. The Swedes are growing trees faster than they are cutting them, the reverse of the policy that prevails in America. Consequently they have wood to burn, but they prefer to cook with water instead. The water falls down faster than the trees can grow up. So they turn it into turbines and with them grind the wood into pulp, and ship it over to America to be made into the yellow journals and silky stockings that are so conspicuous in our country. Electricity is cheap over there and besides they have an ingenious kind of cooking contrivance that keeps in the heat and the steam, so a few watts will cook a lot of food, and it takes a lot of food to satisfy a Swede.

About forty-five per cent. of the farms of Sweden are using electricity for lighting and light power. In the United States "not more than three per cent. of the farms are receiving electric current from power lines," according to G. E. Tripp, chairman of the Westinghouse. California, of course, claims the lead, with 554,000,000 horse-power-hours of electric power used in agriculture during the year 1923, but eighty per cent. of that is employed in pumping water for irrigation. The number of electric power consumers on farms in California is reported as 26,915. Ohio has 17,000 farms supplied with rural electric service and Iowa and Pennsylvania have about 12,000 each.

To read over the list of the applications of the current one would think that the electrical farmer hadn't any chores to do and that the electrified stock were living in the lap of luxury. I am skeptical, as one of my age naturally would be, about the moral effect of all these new-fangled ways. Incandescent lights in the pigpen! Electric fans in the cattle shed! Ultraviolet rays for hogs and hay! Is it good for young hens to be kept up all hours of the night under the white lights, gadding about and stuffing their crops with rich food? Can a thermostat altogether replace the maternal instinct?

And what will be the effect on the farmer and his family? Will he continue his commendable habit of early rising if he can milk a dozen cows at a time by simply turning on the juice? Will not the farmer's wife lose the well-rounded arms that she developed by long hours at the churn and the rosy complexion that she acquired over the cook stove? Will the tungsten filament give that well-grounded education that we, or anyhow our forefathers, got by means of the torch or tallow dip? Will the tennis racket adequately take the place of the buck-saw in the development of the muscles and the sense of duty? In short, will those whose hardest labor has been to press a button or jerk a switch acquire those sterling qualities which have made us what we are?



DR. CARL HERING

IN WHOSE DEATH PLILADELPHIA AND THE COUNTRY LOSE ONE OF THEIR MOST DISTINGUISHED ENGINEERS

A QUEER KETTLE

"If a kettle of water be placed on a fire there is a chance, though an exceedingly small one, that the water will freeze." This startling saying, quoted from Planck by Paul R. Heyl, of the Bureau of Standards, is an admirable illustration of how much the scientific viewpoint of the twentieth century differs from that of the nineteenth.

We were taught in school that heat always flows from a hot to a cold body, and we verified this law for ourselves frequently and sometimes unpleasantly. If we touched a boiling tea-kettle, the heat flowed into our finger before we could snatch it away. If we touched a lump of ice the heat ran into the ice and the finger became cold.

Twentieth-century physicists do not presume to contradict these facts, nor do they propose to abrogate the law, yet they point out that the law is not an ab-

JEAN PAINLEVÉ

SON OF THE DISTINGUISHED MATHEMATICIAN AND FORMER FRENCH PREMIER, WHO HAS HIMSELF WON REPUTATION IN SCIENTIFIC RESEARCH, APPEARING IN A FILM CALLED "L'INCONNU DES SIX JOURS," THE PROCEEDS OF WHICH WILL BE TURNED OVER TO LABORATORIES IN WHICH HE IS INTERESTED. WITH HIM IS MIRKO, A RUSSIAN WOLFHOUND, WELL KNOWN IN FRENCH CINEMA CIRCLES.

solute rule but a statistical average, based upon the calculation of probabilities. It holds in the long run and on the whole, yet there may be, in fact must be, local and temporal exceptions.

Just so a man might say of the Hudson River tunnel that in the morning the crowd flows from New Jersey to New York, and in the evening from New York to New Jersey. Quite true, yet if we look more closely we observe that a minor proportion of passengers are going in the opposite direction from the majority, both morning and evening.

Now from the point of view of the physicist the difference between a hot body and a cold body is that in the former the molecules are moving about more rapidly *on the average*. But the molecules of both are moving with various and varying velocities, and when the two bodies are in contact they influence one another, both ways. Heat *is* continuously flowing from the cooler to the warmer, running up hill, so to speak, but this minor effect is masked by the overwhelming current of heat running down to the cooler body.

Nevertheless, as Dr. Heyl points out, this involves the admission that perpetual motion, which was anathema to nineteenth century science, is theoretically possible on a very small scale, although it is practically impossible on a large scale. In other words, the heat *might* all run from the kettle of water to the fire—only it never does.

DR. WILLIAM CROCKER

DIRECTOR OF THE BOYCE INSTITUTE OF PLANT RESEARCH, A DESCRIPTION OF THE IMPORTANT WORK OF WHICH BY PROFESSOR JOHN M. COULTER APPEARS IN THE PRESENT ISSUE OF THE MONTHLY.

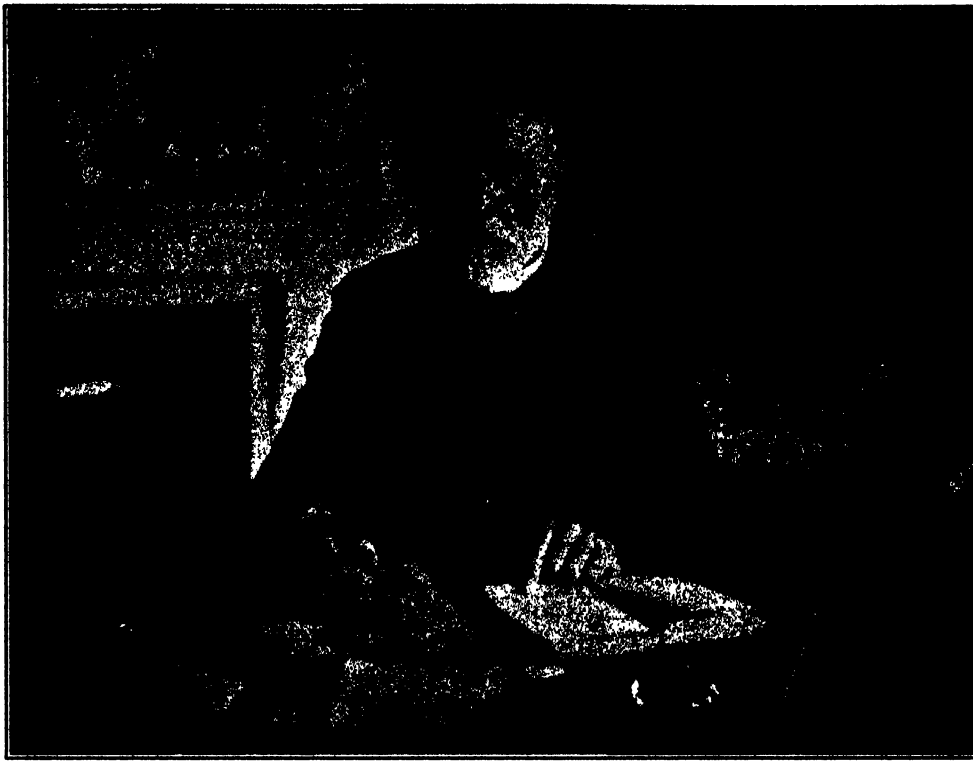
PROFESSOR LUCIEN GALLOIS

BY PROFESSOR DOUGLAS JOHNSON

Columbia University

IN conferring upon Lucien Gallois its Cullom Medal the American Geographical Society has most appropriately honored the distinguished dean of French geographers. Those who know the man and his work will agree that the distinction could hardly have been more worthily bestowed.

Lucien Gallois, who will soon attain the Biblical age of threescore years and ten, looks back upon a long and honorable service in the chairs of geography in the University of Lyons, in the École Normale Supérieure, where he succeeded the founder of the modern French school of geography, Vidal de la Blache, and in the Sorbonne, where he continues to exert a profound influence upon geographical work in France. Here not only do future teachers and investigators of geography benefit by his vigorous analyses and criticisms of their work in a seminar which it is a real privilege to attend; but in public courses of lectures large numbers of laymen hear from his lips masterly expositions of the geographical



Wide World Photos

PROFESSOR LUCIEN GALLOIS

features of their country. One who is so favored as to have him for a guide through the byways of old Paris will profit richly from his inexhaustible knowledge relating to the geographical development of the city; for Gallois is a specialist in urban geography, and Paris is the object of some of his monographic studies.

Outside the university Gallois' influence is felt in many fields. Students of geography the world over know him as one of the leading spirits in creating and maintaining the high character of the *Annales de Géographie*, one of the few really indispensable geographical periodicals published at the present time. Prior to the Paris Peace Conference he served on the French Comité d'Études, a semi-official body created to study problems of the peace which in organization and in methods resembled the "Inquiry" formed in America for the same purpose under the direction of Colonel House. To the publications of this Comité Gallois contributed studies of the Sarre Basin, of the northeastern frontiers of France, of the Rhine River, of the port of Salonika and of other regions politically important. More widely known are his volume on "Régions Naturelles et Noms de Pays: Étude sur la Région Parisienne," and his other writings on Paris and the surrounding country, as well as his contributions to our knowledge of the history of geography in Europe. In France his preeminent position has been fittingly recognized by his election as president of the Association de Géographes Français, while in America many will remember him as an honored guest on the American Geographical Society's Transcontinental Excursion of 1912.

DR. CHARLES G. ABBOT

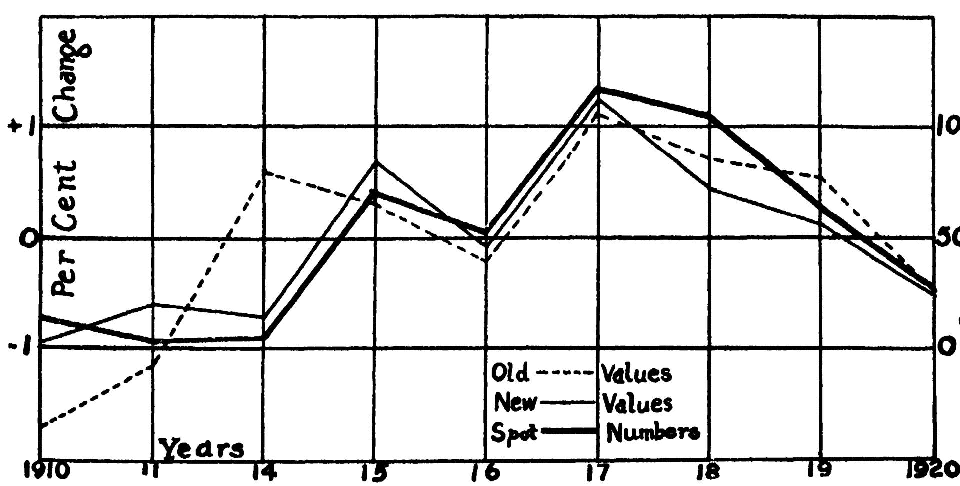
ASSISTANT SECRETARY OF THE SMITHSONIAN INSTITUTION AND DIRECTOR OF THE ASTROPHYSICAL OBSERVATORY, WHO HAS RETURNED FROM AN EXTENSIVE TRIP ON BEHALF OF THE NATIONAL GEOGRAPHIC SOCIETY'S SOLAR RADIATION EXPEDITION.

It is a double pleasure when well-deserved honor is conferred upon one whose high erudition is graced by the charms of a delightful personality; for then both the head and the heart rejoice. This double pleasure was experienced by the friends of Lucien Gallois on learning that he had been awarded the Cullom Medal. Both in his writings and in personal contact he reveals a simple directness of method, a sincerity of thought and a modesty of manner which can not fail to impress all fortunate enough to know him. Those who go to him for help find something more; a man with a big heart, ready to give generously of his time whenever and wherever his rich store of knowledge can be made to serve the cause of geographic science.

VARIATION OF THE SUN'S HEAT

A DEVELOPMENT which bids fair to rank high in weather forecasting is announced in the latest issue of the *Monthly Weather Review* of the U. S. Weather Bureau, by Dr. Charles G. Abbot, of the Smithsonian Institution. That development is the discovery of a new and simple proof by Dr. Abbot that the amount of heat given off by the sun from day to day and from year to year varies. If the proof is final—and it seems irrefutable—there can be no further question that the sun is a real factor in the daily and yearly weather changes. Exact appraisal of its value for long-range weather forecasting awaits only the further perfection of measurements of solar variation and world weather. At all events, an essential element new to weather forecasting has been discovered and proved. Its application is only a matter of research and time.

For thirty years Dr. Abbot has been investigating the sun and measuring the heat it sends to the earth. In 1903 he surmised from his results for previous years that the amount of that heat varied. Urged on by that clue and its



SOLAR VARIATION

THIS GRAPH, DRAWN BY DR. ABBOT, SHOWS THAT THE SUN VARIES. THE DOTTED LINE SHOWS THE CHANGES FOR JULYS 1910–1920 ACCORDING TO THE SOLAR CONSTANT VALUES ALREADY PUBLISHED BY THE SMITHSONIAN. THE BLACK LINE SHOWS THE VARIATION NEWLY DETERMINED FROM MEASUREMENTS MADE ON DAYS WHEN ATMOSPHERIC CONDITIONS WERE IDENTICAL. THE DOUBLE LINE SHOWS VARIATION OF NUMBER OF SUNSPOTS OBSERVED DURING THESE JULYS BY EUROPEAN ASTRONOMERS.

great significance to mankind if true, he has spent the intervening years in elaborate measurements of solar radiation in many parts of the world: at Mount Wilson and Mount Whitney, California; at Bassour, Algeria; at Mt. Harqua Hala, Arizona, and Mt. Montezuma in the nitrate desert of Chile. He developed instruments capable of measuring a millionth of a degree change in temperature, and other instruments of the greatest complexity and usefulness to be used in connection with his measuring instruments for standardizing and for computing results.

The proof which Dr. Abbot now announces appears to finally refute all criticisms and leave no further doubt of the variability of solar radiation. The essence of this proof lies in a comparison of measurements of solar radiation made at times when the atmosphere is practically identically the same. It is obvious that if the atmosphere is the same and the instruments are correct any changes must mean differences in the amount of heat given off by the sun.

Dr. Abbot selected measurements made in the month of July for the years 1910 to 1920, omitting the years 1912 and 1913 because the volcano of Mt. Katmai in Alaska filled the atmosphere of the whole northern hemisphere with dust in those years. During all these years Dr. Abbot and his assistant, Mr. L. B. Aldrich, has measured the sun from the same observatory on Mt. Wilson, California. They used the same instruments throughout and these instruments were regularly tested against standards and found unchanged.

From the measurements made in these months, he selected the days when the atmospheric transparency and its content of water vapor were practically the same, dividing these into comparable groups. All days in any year in which atmospheric conditions were not practically identical with those in other years he discarded.

He then plotted the measurements of the total quantity of heat received at the earth's surface. On the same paper he plotted the solar constant values for these years as previously published. These solar constant values are the result of the measurements of the total quantity of heat received at the earth's surface, corrected by measurements of the loss of heat through the earth's atmosphere so as to indicate what would be found outside it—on the moon, for instance. How closely the two results parallel one another is shown by the accompanying chart.

As a further proof of the accuracy of his measurements of the variability of solar radiation, Dr. Abbot plotted the average number of sun spots for Julys of the same years on the same paper. The harmony is again apparent.

Such is a simplified account of the proof that the radiation from the sun varies over a long period of time closely in harmony with the sun's visible evidences of activity. Dr. Abbot did not stop here, but used a slight modification of the same method to show that short interval changes within the individual months are also verified by this simple process.

With this great step accomplished, the next move is to make the daily measurements of solar radiation as accurate as is humanly possible. To help to accomplish this, the National Geographic Society has given $55,000 to establish a solar observatory at Mt. Brukkaros in Southwest Africa to cooperate with Dr. Abbot's two existing stations in California and Chile. To insure that at least one accurate measurement be made for every day in the year, a fourth station is needed in the northern section of the Eastern Hemisphere.

THE SCIENTIFIC MONTHLY

SEPTEMBER, 1926

RELIGION AND MAN'S ORIGIN

By Dr. C. G. ABBOT

THE sciences now interlink with one another. It is as if the geologists, the physicists, the chemists, the astronomers, the anatomists, the paleontologists, the zoologists and all the rest had been surrounding and reclaiming the great jungle of the unknown. Formerly, this wilderness was so large that the groups of pioneers were quite out of touch or hearing. But as knowledge of all kinds has penetrated deeper and deeper into nature's secrets, the unknown has so far shrunken that the sciences are no longer isolated, and their discoveries overlap and reinforce each other in a most telling way.

Especially is this so in the fascinating problem of man's origin, to which many lines of knowledge contribute their quota of evidence. They all unite to point to the conclusion that evolution, the gradual accretion and modification of organs and functions, is universal, and indicates the rise of man as well as the development of the rest of nature's realm.

Of late, there has been a violent reaction to the growing acceptance of this view from among those who hold that the common English version of the Bible is to be taken as a literal text-book of science as well as a spiritual guide to salvation. They fear that to loosen one's hold upon the literal belief of its statements is to endanger the future of his soul. Hence, it is necessary to state the alternative view of those scientists (and it is believed that they are numerous) who reject neither the evolutionary teachings of science nor the reasonableness of religion.

In the first place, they find it not unscientific to believe in Almighty God. Hardly any work was more celebrated in its time than Dean Paley's "Natural Theology." The author conceives one to be wandering upon a desolate moor, remote from human habitation. He chances to strike his foot upon a round object so curious as to arouse his careful attention. It is, in short, a watch, provided with the little wheels, the springs, the hands, the hour-marks and all the intricate parts we know so well. Although there is no man in sight, or habitation for many miles, there can be but one conclusion. The plain evidence of complex contrivance for a deep purpose demands the previous existence of a highly intelligent contriver. The watch could not just have happened to come into being.

We need not follow here the details of the masterly exposition of this thesis by Dean Paley, although it can be read and reread with growing admiration for the lucidity and power of his exposition. While he argues mainly from the evidences of design occurring in the human body, the argument is equally traceable from the plants with their marvelous interior mechanism; from chemistry and physics with their wonderful structures of atoms and molecules; or from the boundless universe of stars and nebulae. In short, the more one learns of the in-

tricacy and variety of creation, the more admirable appears its contrivance.

But we may consider another aspect of the matter. If these structures of utility be evidences of a wise contriver, suggesting the careful parent providing necessary things for the welfare of his children, the unnecessary yet entrancing beauty of nature may lead us further. A rose, a violet, a sunset, a thrush's song, seem rather the expression of a beauty-loving, benevolent, pleasure-providing Creator, designing not merely necessities but something over and above, adapted to give the purest and most delicately refined joys and pleasures for the promotion of graces of character in his noblest creatures.

There are some who have maintained that the Darwinian explanation of evolution, namely, that it is carried on by natural selection, fully accounts for the complexities and beauties of life, merely as the result of chance variations preserved and guided by the survival of the fittest. One ventures to think that few would interpret the existence and structure of the atom itself (discovered within the past twenty-five years) as a chance modification of the nothing which preexisted, and one would hesitate to maintain with assurance that the admirable organization of the eye or the successive existence of the canker worm would have been apt to develop by pure chance, unless some designing intelligence had controlled selection towards that end. Finally, there is the baffling mystery of the existence of life itself, which in our time seems never to be organized except from preexisting life. All these difficulties are removed by the conception of the creating and guiding activity of God.

It has also been urged by some against these views that since to assume the existence of a creating and guiding God does not enable us to understand the antecedent existence of God himself, we make no progress by the assumption and would better make no hypothesis at all. Such men are called agnostics, for they are those who make no hypothesis regarding the unknowable. Surely one may take this attitude if he prefers it, but others are justified in adopting the reasonable view that obvious contrivance implies a designer, whose antecedent existence, since we have absolutely no evidence available in this life to afford explanation, we adopt on faith. A similar attitude is adopted regarding gravitation. We know it exists, but why we know not. Those who choose this latter type of philosophy walk by sight where they may, but beyond that they walk by faith.

Within this realm where reason no longer gives guidance, it is not contrary to reason to exercise faith in comfortable doctrines. Many men of science do in fact add to their belief in God, faith in the existence of the soul; in a future life; in the usefulness of prayer; acknowledge the gospel of Jesus Christ, and find in the Bible a guide to moral and social conduct, the spur to noble living given by the example of great characters, the spiritual uplift of its sublime passages, and the comfort of its assurances. As with other men, continued practice of the life of faith leads to growth of spiritual discernment also in men of science, so that they appreciate the saying of Saint Paul: "But the natural man receiveth not the things of the Spirit of God: for they are foolishness unto him: neither can he know them, because they are spiritually discerned."[1]

It is true that certain objectors have argued that the existence of the soul is disproved by the reality of evolution. They say, in effect, how or when, and at what exact instant of the slow continuous march of man's evolution could he have acquired a soul? As well ask us to distinguish the exact instant when dawn begins, and, because we can not tell, deny the light of day! Moreover, man is born without intelligence. Shall we

[1] I Corinthians 2, 14.

say that because his prenatal and later development is one continuous progress, therefore he has no mind? Surely he may have acquired a soul by degrees as well as a mind.

While appreciating the worth of the Bible, the scientific believer can not admit that it is an infallible text-book of his science. Why should he? It is certain that different passages of it fairly contradict each other, that its writers believed the earth to be the most important member and center of the system of the heavenly bodies, that many of its laws and narratives express the culture of a semi-barbarous people and that a great deal of its best material is cast in the figurative style. We have become accustomed to teachings in the form of parables, dramas and fictions, but to the Oriental mind such methods are natural, not acquired. As they were used by Christ, so also they were employed by older writers. Compare the introductions to the parable of the prodigal son and the book of Job:

> A certain man had two sons.
>
> There was a man in the land of Uz whose name was Job.

The object of Christ's teaching was not defeated because the exact incident never happened, nor would the philosophical wrestling with the problem of evil in the realm of Almighty God be strengthened by supposing Job a historical character. As John Milton wrote Paradise Lost, why should not a more ancient writer have taken for his theme the Creation?

In short, there is no more reason for attempting to bind modern research into the compass of the astronomy and biology of the Bible than there is for attempting to harmonize the narratives of I Samuel 15, and II Samuel 21 and 24, with the goodness and justice of God, as portrayed by Psalms 103, Micah 6, v. 8, and the Gospels. The whole puzzle is explained by admitting that the Bible is the product of men of unequal spiritual and mental attainments, but containing, nevertheless, along with much which is unedifying, the most sublime and salutary passages which have ever been penned. There are some things in this world that modern progress has not surpassed, and besides the sculpture of Phidias, we confidently include in this category the ten commandments, the sermon on the mount and the wealth of lovely, inspiring and rebuking passages in which the Bible abounds.

Yet this is shocking to some. To them it appears that if we relinquish the idea that every word of the Bible is divinely inspired truth, it ceases to be a guide to salvation. On the contrary, like the racer, so vividly pictured by Saint Paul, who lays aside every weight that he may press towards the goal, the liberation of the mind from acceptance of contradictory and barbarous statements as essential to salvation, frees one to embrace, undisturbed, faith in glorious and comfortable promises. If it be asked how to distinguish what to hold fast and what to pass lightly by, the Bible itself gives the answer in the words of Saint Paul: "Finally, brethren, whatsoever things are true, whatsoever things are honest, whatsoever things are just, whatsoever things are pure, whatsoever things are lovely, whatsoever things are of good report; if there be any virtue, and if there be any praise, think on these things."[2]

The matter of miracles has been a very sore subject. The scientific man is so completely accustomed to seeing natural phenomena repeated with perfect certainty in accord with discovered law that it must be admitted that he is not apt to relish the proposition that for trifling or even unworthy objects the natural course may be set aside. Hence, knowing, as already set forth, the fallibility of the Bible, he is often apt to believe that some, at least, of the miraculous occurrences it records are due to imperfect observation of witnesses or to distortion of accounts in oral transmission.

[2] Philippians 4, 8.

Nevertheless, it may be added that modern discovery makes the miraculous more credible, rather than less so. As far as communication across unbridged space is concerned, this offers no difficulty to the age of wireless. As radio was till recently unknown, other means, not yet understood, of communication from mind to mind may in future be demonstrated.

As for miraculous modifications of matter, it is now the accepted result of physics that all matter, in the last analysis, is resolvable into two varieties, the indescribably small electrons and protons which compose the atoms. These electrons and protons, furthermore, are neither more nor less than equal electrical charges, respectively negative and positive. Electricity is energy. Hence, matter is also a bound form of energy. The all-powerful Creator, the master of energy, may be readily in command of the agencies of creating matter out of nothing, reconverting it into nothing, or, by altering the arrangement of protons and electrons, of changing one kind of matter into another. This, of course, is not all possible as yet to man, nor does he perceive how it might be done, but that it is possible to omnipotence is undeniable. That it would be done by infinite wisdom would seem to demand a worthy occasion.

There is no need to fear a decline in religious faith or spirituality among those whose daily studies lead them to contemplate and admire the hidden wonders of God's creation, and who reverence and attempt to imitate Christ while remaining evolutionists, yet now it is time to inquire what makes them evolutionists. On what evidence are they willing to admit that the human race, like every race of plants and animals, has developed from other types of beings? They regard evolution as the most reasonable explanation of considerations like the following:

(1) In the first place, the life of every individual human comprises a wide-ranging evolution. Conceived by the union of two germs, the prenatal infant passes successively through a variety of forms, many of which resemble foetal or adult forms of other species. Organs more or less rudimentary occur in human beings, either prenatally or even persisting to adult life, which appear to be useless to man, but are similar or closely allied to useful organs in the adults of other vertebrates. Among many such organs are the tail, the vermiform appendix, the toenails. It is even a fact that at a certain stage the organization of the prenatal human approaches that of the adult fish.

One finds it difficult to conceive that it is more derogatory to humanity that the race itself should have evolved in the course of ages from lower organisms than that every single individual actually and unquestionably does evolve within his single lifetime from very primitive forms.

(2) In the second place, man and lower animals have many points of similarity, and much in common. In the skeleton we find a similar organization prevailing. Some of the other vertebrates even present the same number and arrangement of bones. In these cases it is only variations of length and form that distinguish the skeletons of man and animals. The skeletons are clothed with flesh, skin and more or less with hair, in man as in animals. The internal and external organs, such as the heart, lungs, stomach, intestines, organs of smell, taste, hearing, seeing and reproduction exhibit great similarities.

It is not only in matters of form, but also in the emotions and behavior that we find much in common. Fear, love, humor, memory, bravery, intelligent action, are all prominently displayed in lower animals, even in some species very remote in form from man.

(3) The great argument, however, is from paleontology. In many places, the eroding action of streams and the folding of the earth's crust have laid bare

very thick layers of stratified rocks. They frequently contain fossils of many species not now existing. This geological life-record is exhibited, not in one or few places of the earth's surface, but almost wherever rocks have been upturned. If the fossil forms are arranged in orderly array, beginning with those which had been deepest buried, and going on at length to those which lie near the tops of the sedimentary column, they are found to show broad similarities of type wherever found on the earth; and everywhere to present, on the whole, an orderly sequence of change of form from the lowest to the highest layers.

In such a sequence, and representing, as in some cases actually found, a thickness of rock strata of ten miles or more, we may assign names to represent the principal subdivisions of the layer, as selected according to prevailing fossil types found therein.

On the following page is such an arrangement: reading from the bottom and oldest to the top and youngest rocks containing traces of life.

While the whole fossil record is practically never laid bare from the Pre-Cambrian to the Quaternary at any one locality, yet fragments of it of more or less range occur in all parts of the world. The telling thing about them is that, excepting rare cases of accidental burial, the order in which they present fossils is never inverted. We do not find mammalian fossils among gigantic amphibians or among the monstrous reptiles, neither do we find fish fossils among the trilobites of the Cambrian. Fossils of man lie almost superficially, never among those lower strata which are filled with extinct orders and families.

(4) As we can not regard as probable a convulsion which would turn miles of thickness of rocks upside down, so that the earliest deposited should be at the top, much less that such cataclysms should have been prevalent over the world, we must believe that the order of increasing depth corresponds generally to increasing age. This conclusion, if it needed strengthening, finds support in the smoothly rounded forms of the ancient, long-weathered outcroppings of Cambrian age, which may be contrasted with the jagged unworn rocks of recent formations like the Sierra Nevada. This is a question of the character of rocks and length of erosion period.

(5) Thus we learn that there first appeared on earth the simpler creatures like worms and jelly-fish, and other invertebrates, at a later stage the fishes, which are the first vertebrates, later the reptiles and the birds, still later the mammals, and finally, to crown all, man.

(6) These various orders each developed many forms and species, some of which grew to monstrous power and size. But after a period of maximum importance, one by one they became extinct, till now only a few of our existing species can be traced back to the Tertiary.

(7) Under domestication, many forms have changed. Take, for instance, the pigeons, the dogs, the horses or the poultry and think of the extraordinary modifications which have been brought out by skilful breeders, especially in late years when great attention has been paid to this art by scientists.

(8) Variation being, therefore, known and probable, we must reflect that if we consider all the species of animals alive at a given epoch, every one of them will be competent to vary. Those whose generations are brief will be apt to change more in a given time than those of long life and prolonged immaturity, other things being equal. Hence, man, whose generations are among the longest of all animals, will probably change less rapidly than most orders.

(9) We thus perceive that if we make the hypothesis that man is a product of evolution, we are not to think of him as descended from any existing species of animals. All existing species will have changed far more, it is probable, from

Name	Illustrative Thickness	Types of Fossils Found
Pre-Cambrian. Horizon of Scanty Life.	5 miles.	Life forms few but including worm trails, sponges, algae, and crustaceans, all representing extinct families and species.
Cambrian and Ordovician. Horizon of the Invertebrates.	1 mile.	A very rich fauna, including worms, the now extinct family of trilobites, which in the Cambrian was the prevailing form of life, the soft-bodied holothurians, the medusae or jelly-fishes, and the arachnidae, or spider-like creatures and their relatives, but not one single existing species of all these families. The family of the crabs and scorpions was approaching its zenith of size and dominance toward the close of the Ordovician.
Silurian and Devonian. Horizon of Fishes.	¾ mile.	Representatives of the crab and scorpion family become of monstrous size. At the top of the Silurian, we begin to find ray-like fishes, and the Devonian becomes the age of fishes. All species represented are now extinct.
Carboniferous and Permian. Horizon of Amphibians.	1 mile.	Tremendous plant growth, now represented in our coal beds and oil reservoirs, characterized the Carboniferous. Vertebrates of land type first appear in various now extinct amphibians. These approach the salamanders, newts, and frogs. In the Permian, this family begins to culminate in tailed creatures of gigantic form. Still all plants and animals belong to species now extinct.
Triassic, Jurassic, and Cretaceous. Horizon of Reptiles.	1¾ miles.	In this horizon are found a most astonishing variety of enormous reptilian forms, many of which are heavily armored, and many far larger than any animals now existing except the whales. Of eighteen great reptile families, thirteen are now utterly extinct, and of the other five, the lizards, turtles, tuateras, snakes, and crocodiles, the present species are mainly different. Birds begin to occur in this horizon, but of groups now extinct.
Tertiary. Horizon of Mammals.	½ mile.	Forms more and more approximating to the horse, the elephant, the great cats, the bears, the monkeys, and the doglike and other mammals of the present day, appear at horizons of higher and higher level. But numerous of these ancient species, such as the early horse family, the saber-tooth tiger, the mastodon and mammoth, are now extinct.
Quaternary. Horizon of Man.	Superficial.	Man and his works are found only very near the surface (of the stratified column) in the most recent water and land deposits.

the epoch when the ancestry of man was common to the ancestry of some of them than man has himself changed since that epoch. We are not to think, therefore, that existing great apes, though at present nearest in form to man, are in any sense ancestral to man. On the contrary, they are many generations junior to him in the common development.

(10) Still considering the hypothesis that man has developed from lower forms, we must expect to find in fossil

evidences implements representing a less intelligent human culture, and human skeletal remains showing less brain capacity and greater natural means of defense than existing men present.

(11) Such is the case. Archeology leads us back from the age of machinery to the age of metal handiwork, thence to the age of stone handiwork, the implements and artifacts becoming less and less finished and useful, till those associated with fossil man become scarcely implements at all. Sculpture, painting and drawing are found in the caves of France and Spain which, while rude, prove that man was contemporaneous in Europe with the mammoth and other extinct species of animals. Skeletal remains of man himself are found, with more and more heavily built structure and facial features, and less and less volume of brain capacity, the deeper and older the fossil horizon in which they are found. Some of the more ancient of these fossils differ so far from any existing human skeletons as to make it advisable to assign them to an extinct human species, though still superior to existing apes.

(12) In other families of mammals, far longer series of apparently evolutionary forms have been discovered. One of the most complete of these is that of the horse, which presents a succession of animals of growing size and modified organs beginning with Eohippus of the early Tertiary, a little four-toed creature no bigger than a fox, and passing through at least five species of different stages of gradual development in later fossil horizons, culminating in the great Equus, the modern horse, which uses but one toe.

(13) The theory of organic evolution requires for the succession of developments, from the scanty and lowly life of Pre-Cambrian horizons to the mammalian forms of the present day, an enormous extent of time. The earlier evolutionists made demands of hundreds of millions of years upon the bank of time; demands which at that time, over fifty years ago, the physicists and astronomers could by no means see their way to admit. The geologists, however, also demanded for the deposition and weathering of sedimentary rocks in which the fossils are found, almost or quite as great a span of years as the evolutionists. The discovery of radium, and of the nature and transformation of atoms, and the discovery of the nature of the interior of the sun and stars, and of their probable source of energy due to the destruction and transformation of matter—all of these discoveries having come to us within thirty years—have fully reconciled the physicists and astronomers. In the radioactive rocks, they now have a clock which their utmost powers and ingenuity have never shown it possible either to accelerate or retard, and it indicates that our earth has been weathering for about a billion years. Thus, a length of time adequate to bring about the whole progress of evolution seems now to have excellent evidence.

(14) All things change. Among the stars, astronomers can discover unbroken gradations far more complete than paleontologists yet possess of fossils, through which they can trace the evolution from relatively cool red giant stars, hundreds of millions of miles in diameter, and rarer in composition than the gas in a vacuum pump, to the still gigantic blue stars, five times hotter than those dazzling arc lights which gasify even carbon. The gradation proceeds yet further, through a series of stars of descending temperature, more and more ruddy glow, and decreasing size, till the glow fades out altogether, and the star becomes a cool solid like our earth, having lived the star-life and come to the star-decrepitude. In life all things change. Landscapes, families, friends, all grow different as years go by. In fossil forms, changes most extraordinary and tremendous in their import are apparent in every type of life, vegetable and animal.

Why should we think man exceptional? Is it not a sign of hope rather than of degradation? For if he has come to be what he is in a period which geologically is but brief, compared with the duration of the age of reptiles or the age of amphibians, why may we not anticipate for the future a more wonderful man, whose superhuman attributes and powers we can not prophesy?

Such is the groundwork of the evolutionary faith. The confirming facts are so numerous that it is out of the question to attempt to give them here. To do so would require a book of details which would needs be carefully written to avoid obscuring the main issues by the multiplicity of supporting evidences. But it must never be forgotten that no constructive theory is ever proven. One merely arrives at a degree of probability that is evaluated differently by different minds. The destructive critic may pick such a host of flaws in the theory of evolution that the ill-informed may become bewildered, and full of doubt as to whether a doctrine so vulnerable can be worth entertaining.

Similarly, a destructive critic of the contrary persuasion may assault the theory of the inspiration of the Scriptures, and by setting up parallel columns of inconsistencies, statements contrary to Christian kindness, and figurative expressions, omitting at the same time to acknowledge the nobility of the great conceptions therein, he may make the puzzled truth-seeker doubtful if he can without violence to his reason entertain at all the sublime claims of religion. More especially are these methods of argument misleading if they are accompanied, as they often are on both sides, by ridicule and personalities. In such cases they engender heat, not light, and only harm arises.

We must admit that there are many difficulties and shortcomings in the theory of evolution. We are cheered by the rapid discovery of new facts that help to clear up these doubtful places, but it will never be possible to secure as complete and exact proofs as those of theorems in geometry. On the other hand, when we confront such a series of facts as we have described above, supported by thousands of other details not here mentioned, we must consider them. The human mind in all countries and in all ages has ever been prone to explain natural phenomena. Evolutionists are merely following precedent in setting up the best theory they can to include the facts they know.

THE BIBLE AND SCIENCE

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THE Bible is the best of books. It has been too often the worst read of books. The Scriptures resemble a hunting ground where every one bags the desired game. The fundamentalist and modernist, progressive and conservative, pre- and post-millennarian, advocate of election and believer in free will, prohibitionist and anti-prohibitionist, evolutionist and special creationist, Catholic and Protestant, all appeal to the Bible to sustain their respective views. These varied and often contradictory interpretations are apt to bring the Bible into disrepute. People ask if the Scriptures support such differing views, do they teach any true views?

A very common reason for missing the exact meaning of the Bible has been the neglect of historical and grammatical interpretation. Scripture must be studied historically in the light of the time, place and circumstances when it was written. The principles of the ripest grammatical and lexicographical knowledge must be applied to all words and sentences. Happily the scholarly Biblical grammars, lexicons, dictionaries, introductions and commentaries of our time furnish all the tools necessary for an approximate correct reading of the text. Unfortunately, too few use these scholarly works. The result is a conflict of views as to what the Bible teaches.

The interpretation claiming our attention at this time is the prevalent attempt to make the Bible an authority for present-day science. This is inconsistent with the purpose of the Scriptures which were written to teach religion and not science. Proofs of this abound all through the Bible, as the following passages show:

> And now, Israel, what doth the Lord thy God require of thee, but to fear the Lord thy God, to walk in all his ways, and to love him, and to serve the Lord thy God with all thy heart and with all thy soul. To keep the commandments of the Lord, and his statutes which I command thee this day for thy good.[1]

> He hath showed thee, O man, what is good; and what doth the Lord require of thee, but to do justly, and to love mercy, and to walk humbly with God.[2]

> Thou shalt love the Lord thy God with all thy heart, and with all thy soul, and with all thy mind. Thou shalt love thy neighbor as thyself. On these two commandments hang all the law and prophets.[3]

> I am come that they might have life, and that they might have it more abundantly.[4]

> And that from a babe thou hast known the sacred writings which are able to make thee wise unto salvation. Every scripture inspired of God is also profitable for teaching, for reproof, for correction, for instruction which is in righteousness.[5]

All these passages plainly show that the real purpose of the Bible is to reveal our duty to God and man. How remote this is from the effort to make the Scriptures an authority in science. The Biblical writers were spiritual experts and not scientific specialists. Professor Marcus Dods[6] says:

> It is not the object of the writers of Scripture to impart physical instruction or to enlarge the bounds of scientific knowledge. Every writing must be judged by the object the writer had in mind.

Professor H. E. Ryle[7] writes:

> On the other hand, we have no right to assume that, in things distinct from the spiritual

[1] *Deut.* 10: 12, 13.
[2] *Micah*, 6: 8.
[3] *Matt.* 22: 37, 39, 40.
[4] *John*, 10: 10.
[5] *II Timothy* 3: 15, 16, 17.
[6] Genesis, Expositor's Bible, p. 1.
[7] "Early Narratives of Genesis," p. 6.

and moral life, the letter of Scripture is endowed with omniscience. Scripture is divinely inspired, not to release men from the toil of mental inquriy, but to lead and instruct their souls in the things of eternal salvation. In regions of thought within the compass of earthly cognition, the books of Scripture reflect the limitations of learning and knowledge which are inseparable from human composition in their sphere of time and place.

Principal A. E. Garvie[8] says:

All that need be stated in general terms now is this, that we can not accept the Bible as a text-book of science, astronomy, geology, biology, anthropology, or psychology, as in all these departments the writers were limited to the knowledge of their own age and surroundings.

Professor W. H. Bennett[9] writes:

The special object of revelation is no more to inform about history as such, than about geology, astronomy or psychology. Its object is to make God known to men, and to enable men to live in fellowship with God.

Cardinal Baronius (1538–1607) aptly declares: "The Bible was given to tell us how to go to heaven, and not how the heavens go." In discussing a Roman Catholic view of science, Sir Bertram Windle[10] says: "The Catholic is not to be so foolish as to look upon the Bible as a text-book of science, or of any science."

During the past centuries the blunder of opposing Scripture to science should furnish a great warning not to repeat the same error to-day. Thus at one time all believed that the earth was the center and that the sun revolved around it. Copernicus (1473–1542) and Galileo (1564–1642) showed that the sun was the center and that the earth revolved around it. This view aroused a storm of opposition from theologians, Catholic and Protestant alike, who quoted Biblical passages describing the rising and setting of the sun. Copernicus and Galileo were accused of teachings contrary to the Bible. Luther (1483–1546) denounced Copernicus as an arrogant foe who wrote in defiance of Scripture. Melancthon (1497–1560) urged the suppression of such mischievous doctrines by the secular power. John Calvin (1509–1564) asked: "Who will venture to place the authority of Copernicus above that of the Holy Spirit?" Father Melchior Inchofer, S.J., wrote in 1631:

The opinion of the earth's motion is of all heresies the most abominable, the most pernicious, the most scandalous: the immovability of the earth is thrice sacred: arguments against the immortality of the soul, the existence of God and the incarnation should be tolerated sooner than an argument to prove that the earth moves.

Similarly, when Sir Isaac Newton (1642–1727) announced the law of gravity in 1685, it was said that "Newton removed God from his universe and put a law in His place" and that he "took from God that direct action on his works so constantly ascribed to him in Scripture and transferred it to material mechanism."

These are illustrations of the Bible being used in the past to settle scientific questions. We see, to-day, what a mistake this was. Copernicus, Galileo and Newton were right and the theologians were wrong. President Andrew D. White[11] says:

In all modern history, interference with science in the supposed interest of religion, no matter how conscientious such interference may have been, has resulted in the direst evils both to religion and to science.

The science of the Bible is that of the age when it was written. The Biblical authors apparently had no scientific knowledge in advance of their time. The cosmogony of the Hebrews was largely that of the Babylonians as the Babylonian inscriptions show. This was to be expected, for the Hebrews came originally from Babylonia, "Ur of the Chaldees." Furthermore, we now know that Babylonian culture permeated Palestine

8 "Christian Doctrine of Godhead," p. 4.

9 "Faith and Criticism," p. 26.

10 *Current History*, December 1925, p. 338.

11 "Warfare of Science with Theology," I, p. VIII.

from about 3000 B. C. to 1200 B. C. when the Israelites, under Joshua, entered the promised land. Professor O. C. Whitehouse[12] says: "It is to Babylonia, the land of the highest and most ancient Semitic culture, we must look for the most fruitful clues to ancient Hebrew thought and life." Professor S. R. Driver[13] writes: "In fact, no archeologist questions that the Biblical cosmogony is, in its main outline, derived from Babylonia."

In very brief outline the Babylonian and Hebrew cosmogony is as follows. The earth is a flat disc with a large cave called Sheol in the center and with a great ocean beneath. The sun rises in the east and sets in the west. The firmament is a solid vault resting on mountains. Above the firmament is a body of water which comes to the earth through openings. The Biblical creation was completed in six days of twenty-four hours. The chronological data in the Old Testament place the creation at about 4000 B. C. It is hardly necessary to add that the findings of modern science are quite at variance with such a cosmogony. Professor Herbert E. Ryle[14] says:

> The first portion of the book of Genesis deals with the origin of the universe and the beginnings of the human race. The narratives from a modern point of view are unscientific. There is nothing in them of which modern astronomy, geology or biology can take account. Physical science and the Biblical cosmogony, in their description of natural phenomena, belong to wholly diverse phases of thought. The Biblical narrative under the symbolism of primitive folklore represents, as in a series of parables, fundamental religious ideas respecting the beginning of things."

Various attempts have been made to harmonize modern science with the cosmogony of the Bible. Nearly half a century ago Sir J. W. Dawson (1820–1899) in his "Origin of World According to Revelation and Science" (1877), Professor James D. Dana (1813–1895), in his "Manual of Geology" (1880), and Professor Arnold Guyot (1807–1884), in his "Creation or Bible Cosmogony in Light of Modern Science" (1884), made such attempts. These are all eminent scientific scholars. What they say concerning creation according to science is presumably correct. Where they all fail is in their interpretation of the record of Genesis. They read into the Hebrew words forced, unnatural and illegitimate meanings which the soundest Hebrew scholarship can not allow. It is interesting to note that Professor J. D. Dana, in the last edition of his "Manual of Geology" (1895), omits the chapter on cosmogony, with which the book closed in the previous edition, the third, in 1880. No efforts at harmonization are now made by any leading Biblical or scientific scholars. Any one making such attempts to-day would betray a lack of knowledge of the Bible or of science or of both the Bible and science.

Then, too, it must not be forgotten that there are two accounts of creation in the first and second chapters of Genesis. These differ in diction, style, subject-matter and theology. They are from different writers whose conceptions of creation were not the same. These two chapters can not be reconciled with each other. No one has ever attempted to reconcile the second chapter of Genesis with modern science. Professor John Skinner[15] writes:

> Chapter 2: differs fundamentally from Chapter 1: both in its conception of the primal condition of the world as an arid waterless waste, and in the order of creative works: *viz.*, man, trees, animals, woman.

Professor S. R. Driver[16] says:

> The cosmogony of Genesis has not yet been reconciled with the nebular theory of the origin of the solar system and with the succession of

12 Hastings' Dictionary of Bible, I, p. 507.
13 "Authority and Archeology," p. 15.
14 "Commentary on Genesis," p. XXXVIII.
15 "Commentary on Genesis," p. 51.
16 *Andover Review*, Vol. 8, p. 649.

life upon the globe, as these are at present taught by science. Those scientists, who hold that they have succeeded in so reconciling it, are true to science; they do not realize the violence which they are doing to human language as the vehicle and exponent of thought; they do not perceive that they are silently substituting for the sense expressed by the author of the cosmogony an altogether different sense, such as the theory requires.

The branch of science at present violently attacked is evolution. This whole movement is inspired by the belief that it is contrary to the Bible. William Jennings Bryan, in addressing the legislature of West Virginia (April 13, 1923), said: "The Bible condemns evolution, theistic evolution as well as materialistic evolution." In his article in the *Forum* (July, 1925) he writes: "I do not distinguish between theistic and atheistic evolutionists; the former are atheists in the making and are doing more harm than atheists because they mislead more. Evolutionists are iconoclasts; they are bent on ridding the world of religion which they regard as a superstition." The legislature of Tennessee has passed a law (1925) forbidding the teaching of evolution in state-supported educational institutions. In Texas the state text-book board ordered (October, 1925) that all reference to evolution in the books adopted for use in the schools be eliminated by the publishers before they are delivered. The legislature of Mississippi passed (March, 1926) an anti-evolution bill. It is reported that strong lobbies are working in fifteen state legislatures attempting to get anti-evolution bills passed.

As evolution is a purely scientific question of a highly technical order, the man in the pulpit, pew or street is in no position to express an authoritative opinion on such a subject. The banishing of evolution from state-supported educational institutions is a serious blunder. No state or national legislature is competent to decide scientific questions. We must look to the leading experts in biology, embryology, zoology, anthropology, geology, paleontology and other kindred sciences for a correct estimate of evolution. The supreme court in scientific matters in the United States is "The American Association for the Advancement of Science," with over fourteen thousand members, embracing all the leading scientific men of the country. This organization, at its annual meeting in Cambridge, Massachusetts, in December, 1922, affirmed without a dissenting vote the following:

No scientific generalization is more strongly supported by thoroughly tested evidences than is that of evolution. The evidences for the evolution of man are sufficient to convince every scientist of note in the world.

Such an opinion ought to carry infinitely more weight among open-minded people than all the voices which are railing at evolution. In the leading universities, colleges, schools and academies evolution is taught as the best explanation of the facts of life. No other view satisfies so completely all the data. As Professor J. Arthur Thomson[17] says: "The evolution formula fits all the observed data. It is the key that opens all locks."

It can not be too strongly emphasized that evolution is not the cause but the mode of creation. We may call evolution the method used by the Creator in bringing into being the myriad forms of animate and inanimate life. Professor E. G. Conklin[18] says: "It is incredible that the system and order of nature, the evolution of matter and worlds and life, of man and consciousness and spiritual ideals are all the work of chance." We may now read the first verse of the Bible, Genesis 1:1, "In the beginning God created the heaven and the earth" by the process of evolution. The Bible does not tell us anything about the

17 "Concerning Evolution," p. 53.

18 *Scribner's Magazine*, November, 1925, p. 457.

method of creation but only that God created all. It is the province of science to tell us how all was created. In brief the Bible answers, Who? Science answers, How? All assertions then about evolution being opposed to the Bible and its religion must be regarded as absolutely false. Such statements betray ignorance of the Bible and evolution. President Francis L. Patton[19] says: "The anti-evolutionists have been fighting blindly because they have not themselves the scholarship to know just what they are attacking."

The anti-evolution movement is producing certain evils. It is creating an indifference to and a disbelief in the Bible and religion. It is interfering with the progress of Biblical study by filling Biblical chairs with persons out of sympathy with the Biblical learning of our time, as well as by removing competent persons from their professorships. The same movement is preventing the teaching of scientific truth in educational institutions, is sowing the seed of division in churches and religious bodies as well as misinforming the general public on the real facts about the Bible and science.

The anti-evolutionists in their use of the Bible show a strange inconsistency. They quote the Scriptures against evolution, but fail to quote it against several other views accepted by all to-day. Thus the Scriptures assert that the sun rises and sets. Why not consider it a heresy to believe that the sun does not rise or set but is the center of the solar system? The Bible makes the earth a flat disc with a great ocean underneath. Is it not anti-Biblical to believe that the earth is a globe? The sky according to holy writ is a solid vault. Science shows that no such conception is possible. If we are going to make the Bible a final authority as to the mode of creation, as the anti-evolutionists so emphatically affirm, it would seem to be only consistent to make it a final authority in all its scientific statements. By not doing so, the anti-evolutionists really give their case away.

The cause of the anti-evolution movement is found largely in the church. The pulpit in certain localities is half a century behind in Biblical and scientific knowledge. This is also true in some measure of certain theological seminaries and Biblical schools, which are thus furnishing men badly prepared for the ministry. Church people are thus taught erroneous views respecting the Bible and science. A fine illustration of this is the recent evolution trial in a southern state. Such a proceeding would have been impossible in a community with up-to-date pulpit teachings on the Bible and science.

The cure for this anti-evolution movement is a campaign of accurate knowledge about the Bible and science. The pulpit must rise to the occasion and lead this reformation against wide-spread ignorance. Theological institutions must give their students the ripest results of Biblical and scientific learning. Libraries should furnish readers with plenty of popular scholarly books on these subjects. Magazines need to publish more articles on religion and science written by competent authorities. Scientific and Biblical organizations might issue cheap pamphlets containing exact information about these same problems under discussion. Above all, the press, that powerful moulder of public opinion, must co-operate most heartily in this same campaign of enlightenment. The motto of a great university is "veritas vos liberabit." Yes, the truth about the Bible and science is the only means of making us free from error, the error of so many who have zeal without knowledge.

[19] *Continent*, October 29, 1925, p. 1263.

THE PROTECTION OF NATIONAL CULTURE AS THE PROPER BASIS OF IMMIGRATION RESTRICTION

By JEROME DOWD

NORMAN, OKLAHOMA

ONE of the greatest questions, if not the greatest question, for the present generation of Americans is that of protecting our culture from the contamination of the inharmonious elements washed against our shores by the tide of indiscriminate immigration. The maintenance of the existing law for the restriction of immigration or some similar one is the most important obligation of the native-born American patriot. And every patriot needs to realize the fact that it is going to be very difficult to prevent the floodgates of immigration from being reopened. If we would escape such a catastrophe we must keep up a constant vigilance and stand ready to present a united front against any assault upon the ground we have already gained.

At the present time there are powerful influences at work seeking to repeal our existing immigration laws. We have in our country vast hordes of foreign-born people, who have no sympathy or respect for our institutions, and are more interested in tearing down our culture than in assimilating it. They live in segregated quarters, jabber in their foreign tongue and vote for members of Congress who favor unrestricted immigration. All the nondescript and unassimilable racial stocks in our country are opposed to our immigration laws, and, by reason of their united efforts, they wield a large influence in both the House of Representatives and in the Senate of the United States.

During the World War, the people of the United States, after one hundred and thirty years of the open-door policy in reference to immigration, began to put into operation the opposite policy of closure. We discovered that a large number of men drafted into our army and navy could not speak our language, and felt no sense of loyalty to our flag. We came to realize that America was not a melting pot into which every kind of human ingredient could be poured without spoiling the broth.

While our new policy of restriction is an eminently wise one, the arguments which we used to bring it about were not altogether sound, and, if we ever have occasion to legislate again on the subject of immigration, we should have a comprehension of the valid reasons why immigration should be restricted.

One of the arguments that led us to restrict immigration rested wholly upon economic considerations. The labor unions of our country, and also the wage-class generally, had been in favor of restricting immigration for many years, because they perceived that the open-door policy had a tendency to keep down wages and to lower their standard of living. Then, when Europe was in the throes of the World War, many people on this side of the Atlantic feared that, when the war closed, we would be overwhelmed by the tide of immigration from the devastated regions of Europe. This fear was not confined to the wage-earners, but was felt by all classes, and thus there developed a strong public sentiment in favor of curtailing immigration on purely economic grounds.

Economic considerations, however, can not be made the basis for a sound immigration policy. A study of the tide of immigration will show that it adjusts itself automatically to our industrial needs, that during periods of business expansion the tide increases and during periods of depression it decreases. There is little danger of an excess of immigration under normal conditions.

It is, of course, a fact that any increase in the supply of labor affects wages and the standards of living, but these effects have been in operation since the beginning of immigration, and they have no importance now that they did not have at any prior time. As long as our industrial condition remains dynamic, there will be demand for more laborers, and an increase in the supply to meet the demand can have no effects of a serious nature upon the wages or standard of living of our native population.

If the economic motive alone had influenced us in restricting immigration, we would have enacted a law to limit future immigration to a certain percentage of the total immigration to date, and would not have discriminated against certain races by limiting the immigration from each country to a certain percentage of people of that country already here.

The second argument which led us to restrict immigration was based on the assumption that certain races of the world are superior and others inferior and that we should encourage immigration only from the superior races.

Prior to 1885 the racial stocks which composed our population had been mainly Nordic, and it was argued that the Nordic race was the great race of the world, and should be protected, by immigration laws against contamination with the inferior races of Southern Europe and Eastern Asia.

I do not think that there can be found rational support of the theory that the Nordic race is the greatest of world races or that it is superior to any other one of the civilized races.

A number of anthropologists of very high standing hold that, from the standpoint of mental capacity, all the races of the world are equal, that such differences as we find in the culture of races are due entirely to differences of environment and opportunity. All the races, even the aborigines of Africa and Australia, have shown a capacity to pass through European schools of learning.

I do not subscribe to this theory of race equality to the extent of believing that all races are equally capable of the same kind of achievements. I believe that the races of the world differ very much in inherited traits; that they have all developed in different environments, and, in adapting themselves to their respective environments, have acquired special aptitudes and dispositions. For illustration, the Nordic people, by reason of the long and severe winters which keep them indoors, have acquired a propensity to meditate and reflect.

Their reason, therefore, predominates over their emotions. They have self-control, self-reliance and a high degree of initiative. Also, as a result of their sea life and long period of tribal warfare, they have developed pugnacity, daring and love of adventure.

The Mediterranean people, by reason of their sunny skies and outdoor life, have acquired an aptitude for conversation and an acuteness of sensibility to the external world. They have developed a spontaneity and interest in the outer aspects of life such as we observe in all children. Their feelings and emotions are relatively ascendant and respond quickly and delicately to whatever appeal is addressed to them. They are a people, therefore, who have natural aptitudes for the production and appreciation of art.

Thus, the Nordic people and the Mediterranean people have come to have dif-

ferent aptitudes, different types of culture, and, therefore, have made different contributions to civilization.

Now, I am unable to see any rational ground for assuming that the Nordic race is superior to the Mediterranean. If we admit that, in a general way, the Nordic race has excelled in science and that the Mediterranean race has excelled in art, I am unable to understand how it can be contended that a people who produce science are superior to a people who produce art. The Mediterranean people represent a much older civilization, and, but for their expansion into northern Europe, the Nordic people would still be living in a state of barbarism.

I think that the Jews have as much claim as the Nordic people to be regarded as the greatest race on the earth. From the little country of Palestine the western world got its chief spiritual inspiration, and from the Jews of modern times every domain of higher culture has received rich contributions.

I do not think that it will ever be possible to convince rationally minded people that any one race is greater than all the others, and therefore any effort to regulate immigration on such an assumption will be likened unto building a house on a foundation of sand.

The only legitimate ground for restricting immigration is that which rests upon the fact that each nation has a distinctive culture to which it is patriotically attached, and that the protection of that culture against defilement is the fundamental right and duty of each nation.

The culture of a nation consists in its material organization, equipment and technique and its moral standards which underlie its institutions of the family, government, education, religion, art, etc. This culture has its roots in the distant past and has come down to us through a very slow process of evolution. It is embodied in a nation's traditions and it constitutes the discipline which gives character to its citizenship.

Now, it is a sociological law that, in order for a nation to arrive at a high stage of civilization, it is necessary that sufficient time elapse to enable all the elements entering into a nation's life to become harmonized, unified and crystallized into a tradition. In other words, the culture of a nation can not come into a flowering period without first developing a common tradition. For illustration, the chief reason why the people of the United States have not taken a higher rank in science, literature and art is that, being a new country, they have not had the time to develop the models, types, standards and culture groups which are indispensable to great productions in these lines.

Another sociological law is that the contact of nearly related cultures is stimulating to progress and favorable to the development of a flowering period; whereas, the contact of distantly related cultures is antagonistic to progress and tends to retard or indefinitely postpone a flowering period.

Applying these sociological laws to our immigration problem, we find that, up to about 1885, our immigrants brought with them a culture which was nearly related to the culture already rooted to our soil. This immigration was therefore stimulating to progress and favorable to the flowering of our culture. The elements of our culture had been harmonized, unified and embodied in a tradition. We became a nation with a distinct and common culture, and it began to flower about 1840, expressing itself in such celebrities as Longfellow, Lowell, Emerson, Hawthorne, Whittier, Poe.

From 1885 to the World War the immigrants to our shores not only came in greatly augmented numbers but brought with them a culture very unlike our own. Their language, religion, customs and

standards were foreign to our tradition, and could not readily be assimilated to our culture. The immigrants bearing this foreign culture tended to form segregated colonies, where they continued to speak their native tongue and to live according to the customs and standards of their native country.

The presence in our population of these antagonistic and unassimilable elements of culture had the effect of diluting and breaking down our native culture and preventing that process of harmonization which makes for a common tradition and the perfection of national character.

If we had not set limits to this influx of foreign culture the consequences would have been disastrous to our civilization.

There are special reasons why we Americans can not afford to have our culture diluted or confused at this time.

We are already in a state of disorganization and demoralization as a result of a too general and a too sudden breaking away from our traditions. Our intense individualism has caused us to undermine or outgrow the authoritative and disciplinary tradition which has given whatever stability and moral value we have in our domestic, political, religious and other institutions.

This general breakdown of authority and discipline amongst us has been showing itself in a great amount of crime, divorce, insanity, suicide and other manifestations of ill-adjustment to the increasing complexity of social life.

The culture of the immigrants to the United States between 1885 and 1924 was not only different from that of our native population, but was of an inferior type. The earlier immigrants were more idealistic and dominated by fixed principles. The chief incentive which brought them to our country was love of freedom and love of adventure. The later immigrants were more illiterate, more poverty-stricken and more bereft of idealism, and the incentive which brought them to America was self-preservation—the desire to escape the pangs of hunger.

The increasing proportion of our foreign-born population of this type has not only caused a slump in the general culture level of our people, but has caused a falling off in the proportion of distinguished men per million of white population.[1]

It would be the utmost folly to allow our culture to be further disturbed by foreign contact until the elements already in the melting pot have had time to boil down.

[1] Ellsworth Huntington, "The Character of Races," p. 309.

SOME ASPECTS OF NORTHWEST COAST INDIAN ART[1]

By HERBERT W. KRIEGER

U. S. NATIONAL MUSEUM

ALONG the island-studded coast of southeast Alaska and of British Columbia are numerous villages and settlements of native Americans known as the Northwest Coast Indians. Many of these villages are no longer occupied by their former inhabitants, while others show evidences of neglect because of the absence of their owners, who are working in the canneries or who are imitating the white man's ways and are living in new houses constructed of sawed boards, which are all too often fashioned from flimsy and makeshift materials, while the abandoned ancestral home, which represents the highest skill of the northwest coast Indian, is allowed to fall into decay.

The house architecture, sculpture in wood, horn, slate and the wood carver's arts of the northwest coast tribes have aroused wonder and admiration from the time of their discovery by the Russian explorer Behring, who first landed at what is now called Sitka, Alaska, in 1741. The earliest account of their peculiar arts dates back to descriptions written by Captain Cook in 1778.

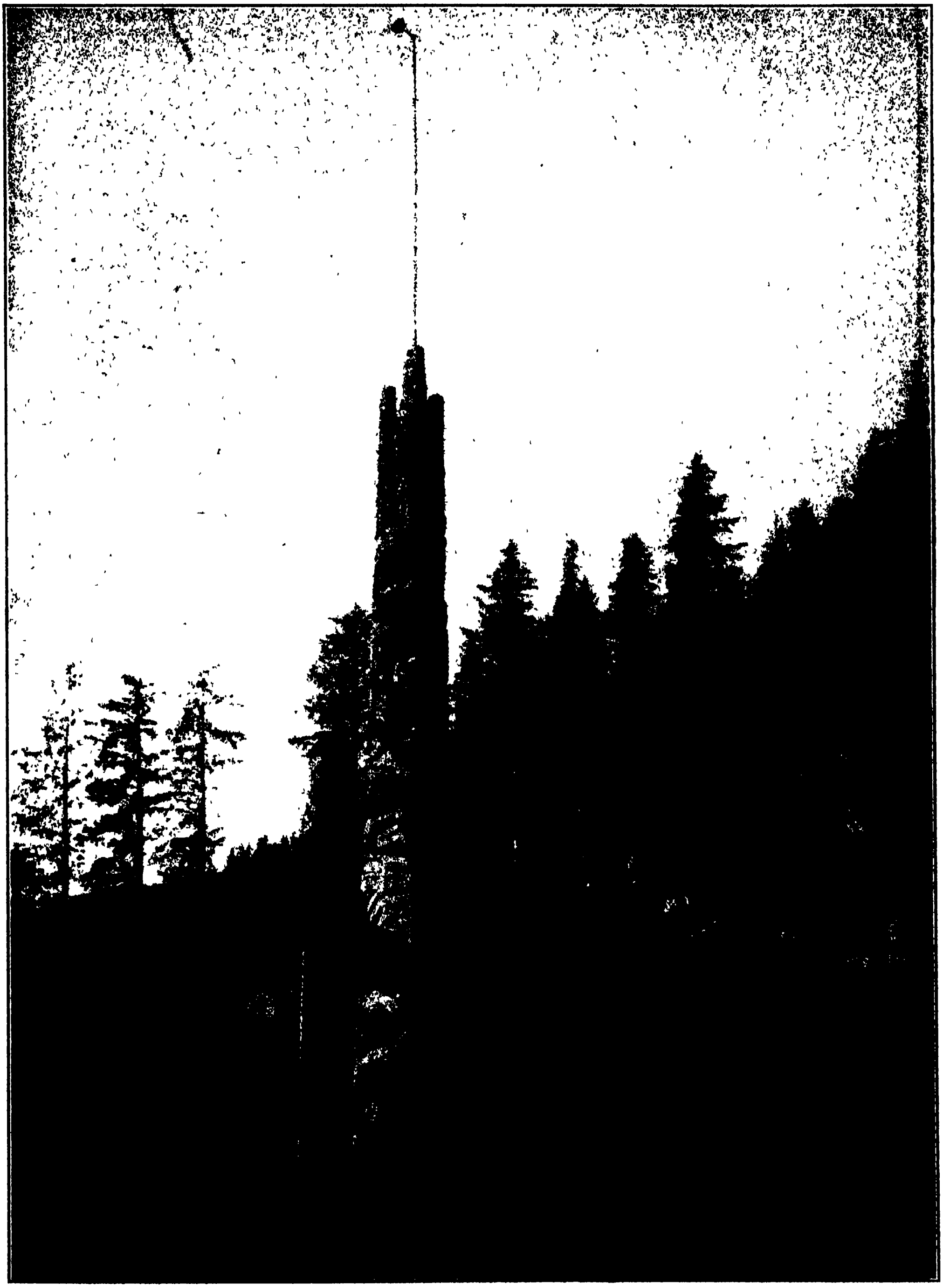
Nowhere else in the world may one find a similar type of art representing for the most part the carved figures of animal forms. The carved images are usually of well-known animals, such as the beaver, bear, killer-whale, shark, hawk, eagle and raven, but are also of mythical creatures, such as the thunderbird, which makes lightning by the flash of its eyes and thunder by the clapping of its wings, and various others not found in the natural history books.

These carved images find expression on the tall wooden totem poles, house posts, dugout canoes; in fact, almost every object of daily use from a musical instrument to an artistically carved cooking pot of cedar wood. The designs are usually in low relief but are duplicated in paintings in native colors on house fronts, on boxes and in textiles and basketry.

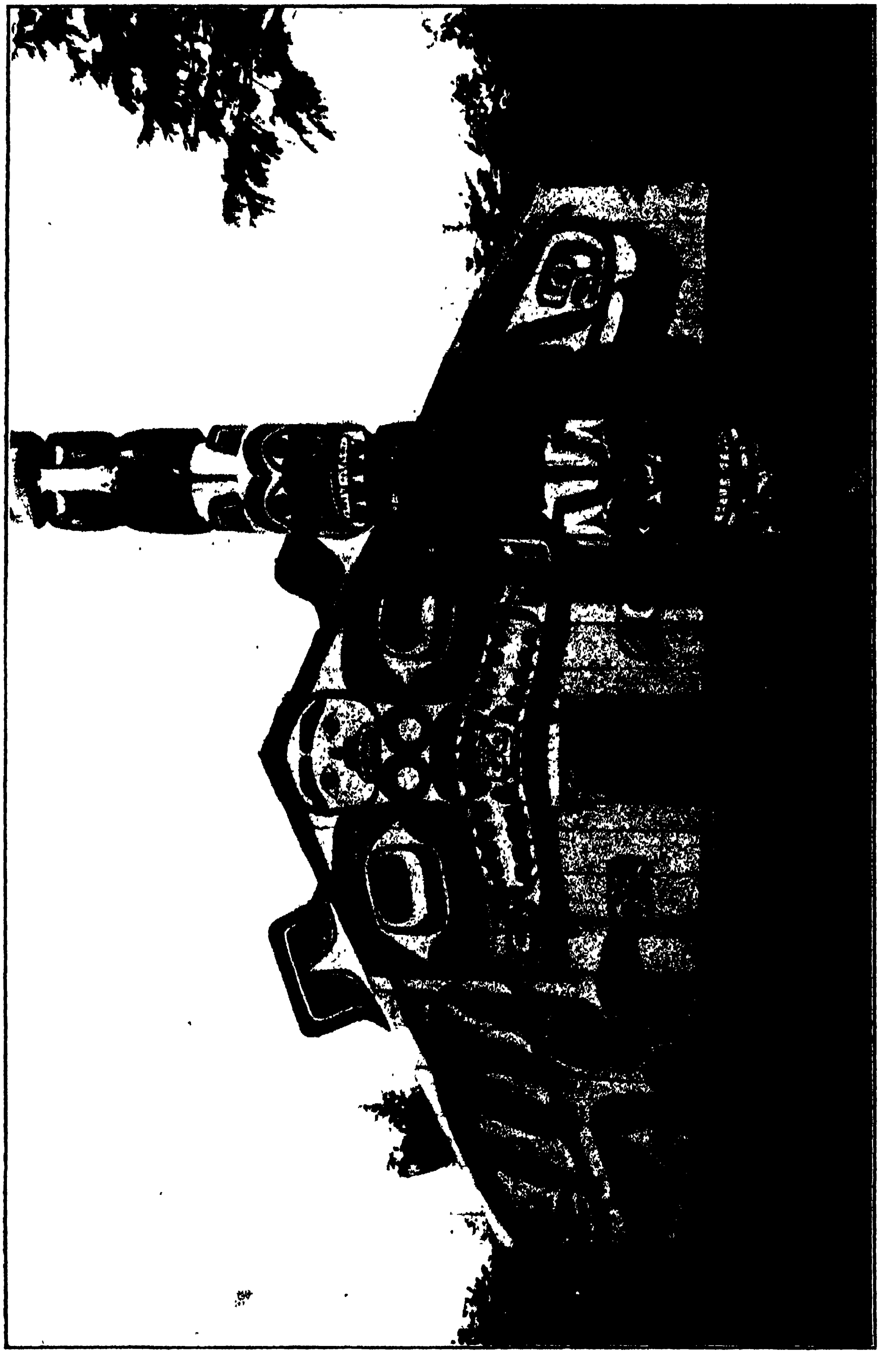
The most striking objects on which the native lavishes his best artistic efforts are the tall columns of cedar wood familiarly known as totem poles, but which are really memorials, or, as we might say, tombstones, erected in honor of the maternal male relative whose property the builder had inherited. These totem poles are, of course, not built of stone but from the hollowed trunks of the giant yellow cedar. They are not set up in a cemetery, as with us, but occupy, instead, the place of honor at the center of the gable end of the owner's house.

The origin of the arts of the northwest coast Indians has never been satisfactorily explained. It has been suggested that they may be ascribed to a recent Asiatic influence or to migrations of peoples from the islands of the south Pacific Ocean, among whom the arts of wood-carving are well developed. Another explanation offered is the effect on the daily life of the natives of the extremely mild and humid climate of the northwest coast and the so-called Alaskan panhandle. At Ketchikan, near the southern boundary of southeast Alaska.

[1] One of the Smithsonian Radio Talks, arranged by Mr. Austin H. Clark; broadcasted from Station WRC, Washington, March 25, 1926.



A NATIVE HOUSE AND TOTEM POLE AT SKIDEGATE,
A HAIDA INDIAN VILLAGE ON THE WEST COAST OF QUEEN CHARLOTTE ISLANDS, BRITISH COLUMBIA. THE HOUSE ENTRANCE THROUGH BASE OF POLE HAS BEEN SUPPLANTED WITH MODERN DOORS AND WINDOWS. CARVINGS OF GRIZZLY BEAR MAY BE DISTINGUISHED NEAR TOP AND BOTTOM OF THE COLUMN WHILE THE RAVEN OCCUPIES A PLACE AT THE CENTER.



AN OLD PAINTED HOUSE FRONT

OF THE KWAKIUTL INDIANS AT ALERT BAY, VANCOUVER ISLAND, BRITISH COLUMBIA.

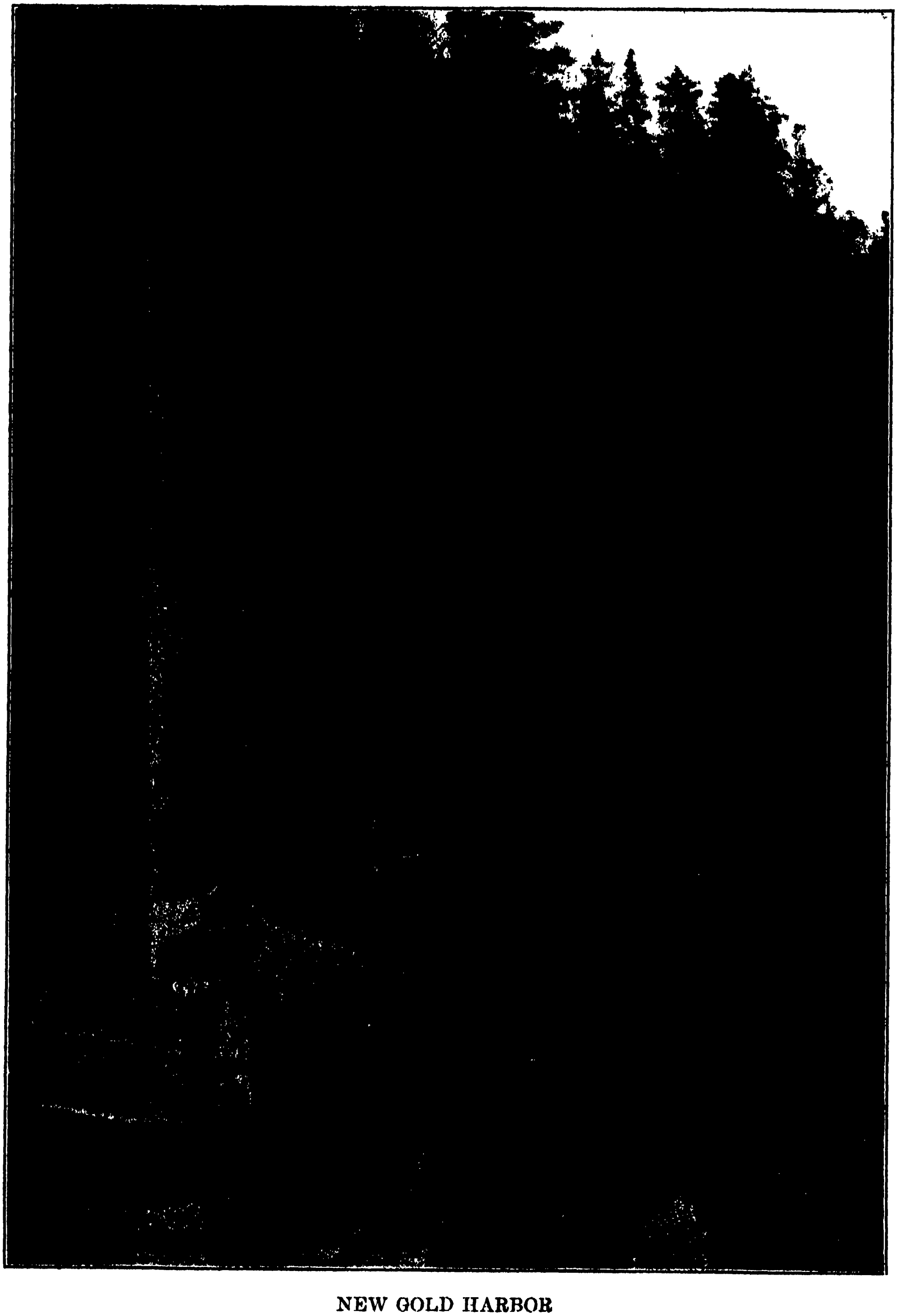
the average annual number of rainy days reaches a total of 235. Dense forests of beautiful cedars supply materials for most of the native arts and crafts. The fondness of the Indians for working in wood becomes almost an obsession with them and find expression, for example, in the long seaworthy dugout canoes hollowed from a single cedar trunk. These boats are constructed with a high prow and stern, each carved with representations of mythical and realistic animal forms. The vessels are fitted with sails and are often used on fishing expeditions carrying parties of forty or more men hundreds of miles from their native village. The birchbark canoe of the interior northern tribes or the skin-covered boat of the Alaskan Eskimo is unknown to them. In a similar manner do the northwest coast Indians differ in almost every particular phase of their daily life from the other neighboring Indian tribes of Alaska, British Columbia and the state of Washington on the south.

A complication in the question regarding the origin of the highly specialized art and material culture of the northwest coast Indians may be noted in their former practice of wearing armor consisting of jackets of slats and rods of wood or bone. This custom was clearly borrowed from the peoples of Asia, many of whom wear similar coats of mail. To offset the significance of such proved contact with Asia in comparatively recent times is the absence among them of certain other Asiatic traits, such as the making of coiled baskets, a trait which has spread throughout the Indians of western America as far south as Mexico and eastward to the Great Plains, including the tribes immediately surrounding the northwest coast area. These neighboring tribes have also borrowed another trait from Asia, namely, the construction of semi-submerged earth-covered houses. Such dwellings are typical of northern Asia over an area extending as far east as Europe, but are not characteristic of the Northwest Coast Indians. There fore, as stated before, the origin of the culture of the northwest coast remains obscure.

When one refers to the civilization of native America, one thinks immediately of those traits which reached their highest development in Mexico and Peru just before the days of the Spanish Conquest—the practice of agriculture, together with irrigation, and the use of the hoe; the domestication of certain animals; the building of smoothed stone structures and temple pyramids. The growth of cotton, thread spinning and the use of the loom; the making of pottery, together with the use of tobacco and the wearing of sandals or moccasins, are the essential traits of native American civilization. Not one of these traits was known or practiced by the Northwest Coast Indian. Still, in his own specialty, in wood-carving and in the artistic representation of realistic animal figures, in low relief carving on wood, stone and horn, also in painting of realistic or mythical animal figures and in textiles and in basket designs, the Northwest Coast Indian has no equal.

They build their houses of planks split from cedar trunks with the aid of only the crudest tools and wedges. These houses have a true frame structure and are skilfully fastened with cedar bark without the use of nails or pegs. Some of their houses are several hundred feet long and as much as fifty feet wide. They are built with the gable end facing the beach, which is reached by a plank stairway leading down to the water's edge. In front of the house and usually at the center of the gable end is the totem pole (fig. 4). The entrance to the house is a hole cut through the base of the totem pole.

Among the Tlingit and certain other of the northwest coast tribes the totem pole has a hollowed cavity in the rear of the pole in which the cremated remains of the one in whose honor the me-



NEW GOLD HARBOR
A HAIDA INDIAN VILLAGE IN THE QUEEN CHARLOTTE ISLANDS, BRITISH COLUMBIA.

morial was erected are placed. Nearly all the poles standing at the present time have such cavities for the storing of the remains of the deceased maternal ancestor from whom the present owner inherited the property. Among the Tlingit the name for totem pole is the word meaning coffin; its use and significance would make it according to onr notions the equivalent for tomb-stone or memorial column.

The erection of a memorial to his uncle of necessity includes carved representations of animals and events illustrating the traditions and genealogy of the family, together with carved images of the family animal totem or crests which are the reputed remote animal progenitors of the particular clan and family to which the owner belongs. All this does not preclude, however, the right of the owner to introduce carvings illustrating some particular experience or event in his own life which might add weight to his bid for fame.

Most people think of art and of artistic patterns as of something tacked on, something supplementary to, the essential parts of an object. That useful things may in themselves be pleasing in outline without conscious additions made for artistic effect is not always realized. The art of the northwest coast Indian is unusual in that the totem pole which he erects is pleasing in itself, although not intended primarily to please but rather designed to impress the beholder with the owner's greatness or wealth or position in society, and to induce respect for himself as the heir of the family crest and totem, all of which are expressed on the pole, usually at the base, center and top. The Indian has inherited the right to the crests and totems representing the traditional animal protector of his uncle or mother's brother, together with his mother's family or clan name and rank.

Much stress is laid on the possession of wealth. The desire for the accumulation of property stirs them to the limit of their effort and ability. Religious ideas and mythical wealth-producing, half-animal creatures are called to aid in the pursuit of gain, so that many figures carved on the totem pole represent mythical beings whose presence there on the totem pole insures the prosperity and future wealth of the owner.

Totem pole art is almost entirely a representation of animals. These representations refer for the most part to the rôle played by certain animals as actors in native myths. To properly understand the carving one must know the story of the myth. Then, to make the totem pole art still more abstruse, the Indian artist has certain rules of procedure which obtain for him the desired results but which make the representation of animals unintelligible to us unless the rules are also known.

He adds certain parts which convention dictates must be added; or he may simplify and represent only what are to him the essential animal parts.

The curved beak of the hawk is invariably represented as touching the mouth on the under side, while the thunder-bird which wears a cloud hat has a larger beak. The raven has a long straight beak, while that of the eagle is short and curved. Birds, even when they take human form, are to be recognized by a beak added to an otherwise human face.

The beaver usually has a stick in its mouth, which it holds between its paws. The large projecting incisor teeth and scaly flat tail are further characteristics. Certain mythical water monsters may take on a variety of forms. Animal representations have erect ears placed above the eyes, but are otherwise often difficult to distinguish from human figures. Stock objects or fillers in occupying the spaces on the totem pole between the totemic crests are such minor animals as frogs and ground worms.

MEMORIAL POLE IN THE PARK AT SITKA, ALASKA

THIS POLE WAS ORIGINALLY ERECTED AT KASAAN VILLAGE, NOW WITHIN THE NATIONAL MONUMENT OF OLD KASAAN. THIS POLE WAS GIVEN TO GOVERNOR BRADY BY JIM PEEL'S FATHER. IT IS SUPPOSED TO BE ALASKA'S MOST ELABORATE COLUMN.

The bear is usually carved in a sitting position and holding a stick between his paws. The tongue usually protrudes from his mouth.

The shark carvings may be recognized even when represented in human form by three parallel markings on the cheeks representing gill slits. The forehead rises in a triangular shaped lobe, while the downward curved mouth is drawn back exposing sharp triangular teeth. Other fish are distinguished by their fins. The killer-whale is characterized by the prominent dorsal fin.

The most important thing in the life of the Indian is his crest or totem. Representations of this animal crest are placed on every conceivable object of daily use; they are even tattooed on his arms and body and are painted on his face. The inheritance of a proper kind of a crest or totem determines an individual's chances for success and for a favorable standing in the community. As he inherits the crest or totemic animal protector from his mother's male relatives, he makes it his business to erect a memorial column or tombstone to his maternal uncle as soon as he is financially able to do so. This totem pole has carved on it, as mentioned before, the symbolical and often distorted or simplified animal figures representing his inherited family glory or experience. It may be only after years of saving and effort that an Indian is able to erect the column which firmly establishes his place in the estimation of his fellows.

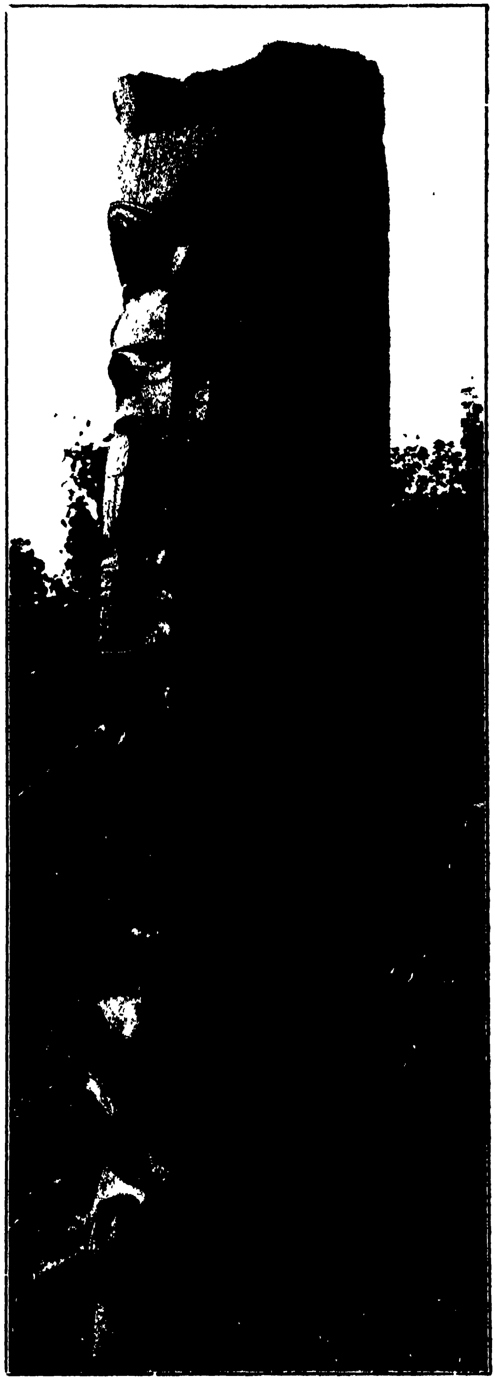
At the time of the erection of his totem pole to the memory of his maternal uncle, it is customary to give away a large amount of property, such as blankets, canoes and in former times even slaves. Such feast or property distribution has come to be known as a potlatch. The giving of a potlatch by an Indian establishes his right in the community to a totem pole. The amount of property distributed among the villagers depends on the size of the pole. The height of the pole, in turn, is de-

termined by the number of animal crests or totems and the rank of the maternal uncle which the builder of the totem pole is to inherit. An Indian would be laughed at by the inhabitants of the entire village if he erected a large pole but did not possess adequate means to distribute sufficiently substantial gifts at the time of the raising of the pole or if he assumed animal crests which were not traditionally his to assume.

Any unusual experience in the life of the individual may be incorporated in the carvings on the totem pole. One pole has the carved figure of a ship under full sail. This pole belonged to a woman who was the first of her village to see such a vessel and the white men who landed at Sitka, Alaska.

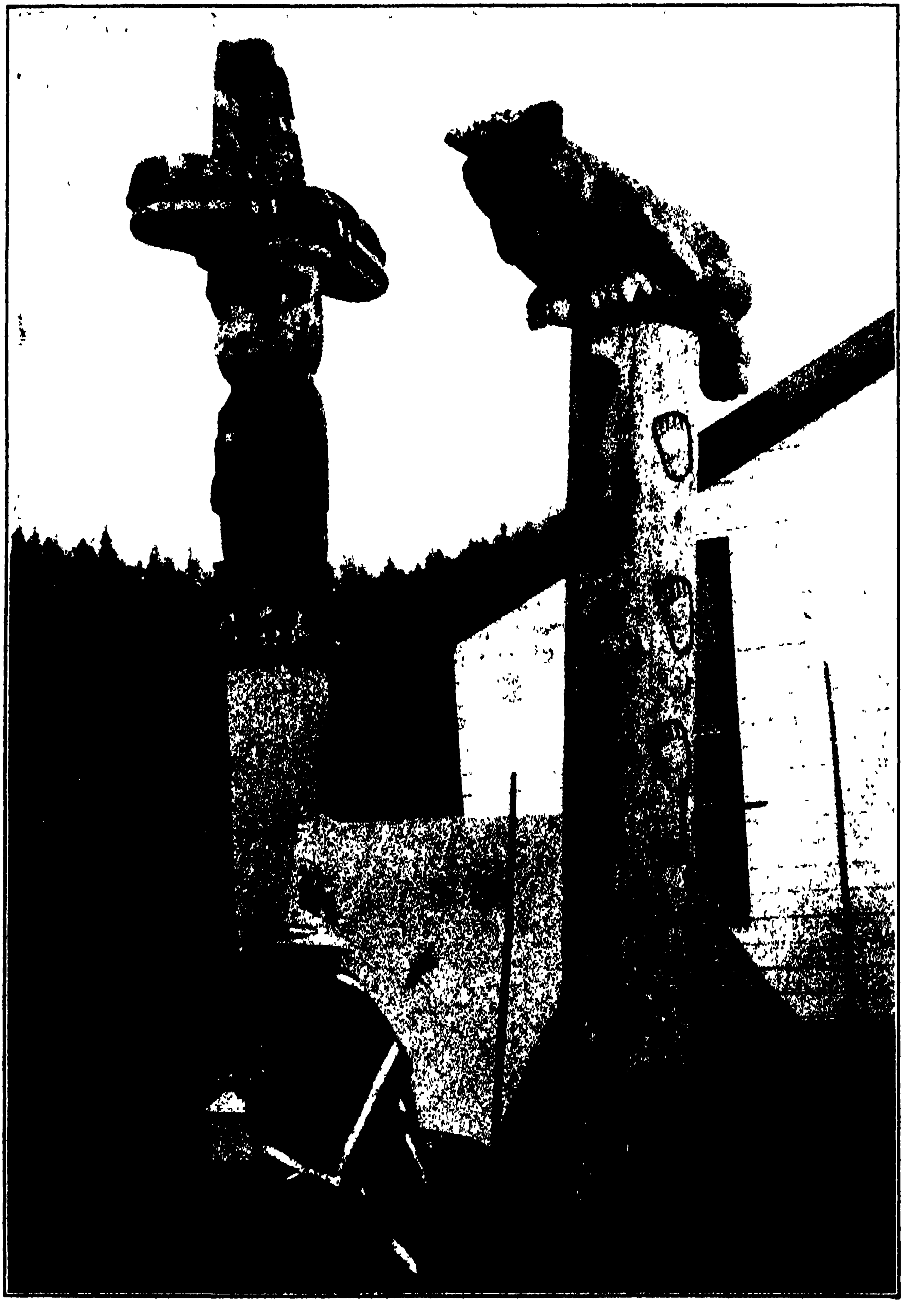
Another carved figure on a different pole represents the experience of an Indian at Tongass village who once acted as host to a former secretary of the interior who was visiting Alaska. The secretary was asked to sit on a pile of fine furs in the house of the Indian. At the close of the interview he was told that he was forgetting his furs. "It is the custom of our people," said the Indian, "that what a visitor sits upon is his." When the Indian's totem pole was erected later by his nephew, the former secretary of the interior was represented on it dressed in a frock coat, stovepipe hat and checked trousers.

The story is told of another pole, also located at Tongass village. This pole belongs to an Indian of the Bear clan, that is, the family protective or totemic animal crest was the bear. This Indian had at a former time given a potlatch or feast to a rival chief whose crest was the killer-whale. This rival chief lived at Wrangell and later through drunkenness lost all his property so that he could not give a potlatch in return, which was the customary thing for him to do. This experience of the Indian of the Bear clan was represented on a pole erected by his nephews by carvings of the uncle's bear



DETAIL OF TOTEM POLE

ORIGINALLY ERECTED AT SKIDEGATE VILLAGE, QUEEN CHARLOTTE ISLANDS, BRITISH COLUMBIA, NOW IN THE PROVINCIAL MUSEUM AT VICTORIA, BRITISH COLUMBIA.



MEMORIAL COLUMNS

IN FRONT OF THE HOUSE OF THE HEAD CHIEF AT WRANGELL, ALASKA. THE GRIZZLY BEAR ON THE POLE TO THE RIGHT IS THE TOTEMIC FAMILY CREST OF THE NANYAAYI CLAN; THE FIGURE ON THE POLE TO THE LEFT IS A MYTHICAL CREATURE SUPPOSED TO BRING GOOD LUCK. ON THE BEAR'S HEAD A NUMBER OF SMALL PLANTS ARE GROWING.

totem biting the dorsal fin of a killer-whale.

Another example illustrating how strange carvings may find their way on totem poles may be seen on a pole erected in honor of one of the first converts to Christianity, at Sitka. A carving at the top of the totem pole represents Saint Paul. This was copied from an illustration in an old Bible in the Russian church at Sitka. The carving is probably responsible for the old story about the absurdity of a saint on a totem pole.

The following story is told by Dr. T. T. Watermann to illustrate how carvings placed on a certain totem pole sometimes refer to events occurring in the life history of some mythical animal hero. A certain family, whose totemic crest was the Raven, lived at the town of Kasaan, which is now known as the National Monument of Old Kasaan. This family represented on its pole the legend known as "raven traveling." At the top of the pole is raven himself, in human form. Below him is his likeness in bird form. The impish look that the artist managed to obtain in his wood carving would be difficult to reproduce. It might be said here that all animals know how to remove their skin and to assume human form for the time being. All bears are known to hang up their hides in their den from time to time and to assume human form at will. On this particular pole placed just below the raven carving is a fish called sculpin or bull-head—a very ugly and repulsive appearing fish.

Bull-head used to be a beautiful fish. The raven noted for his trickery was walking along the shore and saw bull-head in the water. Raven called out to him, "Come on shore one moment." Bull-head paid no attention. "Come ashore a moment," said raven, "you look just like my grandfather." "I know you," said bull-head, "you might as well be still. Future generations also will know what kind of a person you are." Bull-head was thus too smart to come ashore. "Well, then," said the raven, "from this time on your head will be big, and your tail will be skinny, and you will be ugly." In spite of his smartness bull-head is to-day one of the ugliest of fish.

FRANCESCO REDI, THE FATHER OF EXPERIMENTAL ENTOMOLOGY

By HARRY B. WEISS
NEW BRUNSWICK, N. J.

FROM an examination of the conventional texts on entomology, one would never suppose that the science had any background whatever, historical or otherwise, so carefully are all references to very early writers and workers omitted. I have wondered often why a chapter at least could not be devoted to the early history of entomology, not in this young country but in the world at large. Perhaps some day some one will write retrospectively on the subject, not neglecting to begin with the religious beliefs of the ancient Egyptians with which the scarabaeus was so intimately entwined.

In comparison with Aristotle, Pliny and others, Redi is quite recent, but it remained for him to explode by experimentation the long-held theory of Aristotle concerning the spontaneous generation of lower animals, even though disbelief in Aristotle's doctrine had been previously expressed in print by Giuseppe Aromatari of Assisi in his work "De Rabia Contagiosa" (1625). Redi's book, "Experiments on the Generation of Insects," which appeared in 1668, while dealing mostly with the results of his various experiments, includes also the opinions of philosophers of the period and many quotations from the classics, all designed to round out, historically or otherwise, his own work.

In an effort to trace the truth in the ancient and then modern and popular belief that decayed matter produced worms, Redi placed in his open breeding cages or boxes such a miscellaneous assortment of materials as dead snakes, a pigeon, a piece of veal, a portion of horse-flesh, a capon, a sheep's heart, a fish and skinned river frogs. He noted the visits of flies, the deposition of eggs, the feeding of the maggots and finally the pupae which gave rise to various species of flies. He continued his experiments, using the raw and cooked flesh of the ox, deer, buffalo, lion, tiger, dog, lamb, kid, rabbit, duck goose, hen and swallow, and found that, as before, various species of flies were bred, sometimes all from one piece of flesh. He concluded, therefore, that all worms found in meat arose from the eggs of flies and not from the decay of the meat. However, in order to confirm his theory he continued the experiments and devised new conditions. He put some of the food substances in sealed flasks so as to exclude the air, and others in containers covered with a "fine Naples veil," so that the air had access to them. Meat was buried under the ground, and the work was repeated at different seasons, using different containers. No flies were bred from the sealed containers, nor from those covered with veils, nor from the buried meat. In this way he proved to his satisfaction that flesh did not become wormy spontaneously.

Concerning cheese worms, although he performed no extensive experiments, his previous work with flies led him to believe that the eggs were laid in crevices of the ripening cheese, the maggots later burrowing into the tender heart of the cheese, as opposed to the explanation of Gassendi that flies having deposited their eggs on leaves and grass eaten by cows, sheep and goats, these eggs were finally

introduced into the milk and cheese, where they developed into worms or maggots.

After numerous trials in which cucumbers, strawberries, pumpkins, pears, apples, plums, lemons, figs and peaches were utilized, Redi found that such materials, either raw or cooked, did not grow wormy if kept in protected places, but if left in exposed places produced different kinds of insects according to the eggs laid on them.

He believed that, although all dead flesh, fish, plants and fruit constituted good breeding material for flies and other winged animals, fungi rooted in the ground or on trees produced a quite different kind of worm, and that whatever was responsible for the worms in live fungi was also responsible for those in living plants and fruits. He notes the opinions of two other philosophers as follows:

ESPERIENZE
Intorno alla Generazione
DEGL'INSETTI
FATTE
DA FRANCESCO REDI
Gentiluomo Aretino, e Accademico della Crusca
E da Lui scritte in una Lettera
ALL' ILLVSTRISSIMO SIGNOR
CARLO DATI.
Quinta Impressione.

IN FIRENZE. MDCLXXXVIII.
Nella Stamperia di Piero Matini, all' Insegna del Lion d'Oro.
CON LICENZA DE' SVPERIORI.

TITLE PAGE OF REDI'S BOOK

REPRODUCED FROM THE 1909 TRANSLATION PUBLISHED BY THE OPEN COURT PUBLISHING COMPANY

Fortunio Liceto, in his book on the spontaneous generation of living things, being convinced that the vegetative soul, more ignoble than the other, can not produce the sentient soul, believes that the generation of worms is due to the nourishment that plants take from the ground, in which, he says, there are many particles of the sentient soul communicated to it by the putrefaction of animal bodies, or by their excrement; he further adds that from all bodies, living or dead, many atoms or corpuscles, pregnant with the sensitive principle, are given off, fly about in the air and attach themselves to the bark of trees, plants and to their leaves and fruits, and subsequently cause the origin of worms.

Pietro Gassendi thinks that worms breed in the pulp of fruits owing to the insemination of the flowers by flies, bees, mosquitoes, etc., their seeds afterwards developing with the fruit, become worms.

Redi expresses his own belief in the words:

But if I must disclose my real feeling in the matter, I would state my belief that fruits, vegetables, trees and leaves become wormy in two ways. One way is that the worms come in from outside, and, seeking food, gnaw a path to the very heart of the fruit and the wood. The other way, which I esteem worthy of credence, is to be found in the peculiar potency of that soul or principle which creates the flowers and fruits of living plants and is the same that produces the worms of these plants. Who knows? Perhaps many of the fruits of trees are produced with a secondary, rather than a primary purpose, not as preeminent in themselves, but as objects of utility, destined as a matrix for the generation of those worms, which remain in them for a determined length of time, and thence come forth to enjoy the sunshine.

As to galls, he suspected, before his experimental work on the generation of insects, that the fly made a slit in the young twigs of oak and inserted an egg therein, the gall arising therefore and being a sort of disease caused by the fly's sting. He was not sure whether the galls appeared first and the flies later impregnated them with a seminal fluid that helped to produce the worm. He reflected, however, that many fruits and vegetables protected by rinds and pods

became wormy and observed that galls arose in young parts of the plants and developed with the plants. In view of this, he changed his mind and thought "it probable that the generation of worms in trees" did "not occur fortuitously, nor" did "it proceed from the eggs deposited by flies, especially as every gall or growth has its own peculiar kind of worm, gnat or fly, which never varies." He further defends his view as follows:

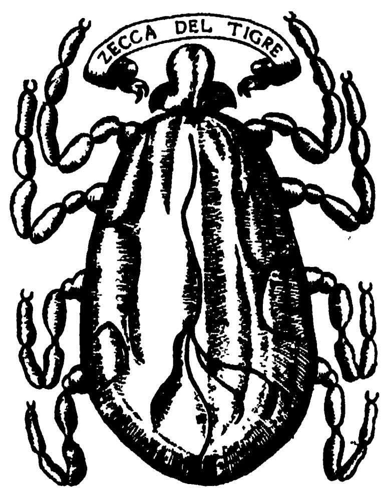
> I do not consider it a great sin against philosophy to maintain that the worms of plants are created by the same natural principle that produces the fruits of the plants; and although in some schools it is held as an axiom that the lower can not produce the higher, I think this absurd, for it seems to me that the fact alone of flies and gnats being bred in galls is sufficient to remove all doubt. Besides, "low" and "high" are unknown terms to Nature, invented to suit the beliefs of this or that sect, according to the needs of the case. But even if it were true, as the scholastics noisily assert, that the lower can not produce the higher, I do not, for my part, see what there is degrading or paradoxical in the assertion that plants, in addition to their vegetative existence, possess a sensitive power to which this is subordinate, and which enables them to produce animal life.

Redi accounted for the presence of worms in cherries by the same theory. As for the worms in filberts he was undecided whether they entered from without or were "generated by direct procreation of the tree," but finally believed that they came from the outside.

He bred caterpillars through to butterflies, and noted egg deposition, but was still doubtful, as the following quotation shows:

> I tried a great many other experiments, and made many observations, but owing to carelessness, some pages, on which I had inscribed them were mislaid; hence not wishing to trust to my memory, I shall pass on and tell you that it is possible that there is some kind of tree, which can engender caterpillars, undergoing the usual transformation from chrysalis to butterfly. I do not affirm this, neither do I deny it.

He was not able to witness cabbages produce caterpillars, as Aristotle asserted, nor mulberry trees "engender" silkworms, as claimed by Father Kircher. As to tapeworms, liverworms of sheep and larvae in the nasal passages of sheep and deer, these were supposed by Redi to have been produced by a vital force, similar to the one active in the case of the cherry worm, oak galls, etc. He thought that the same force might possibly be responsible for the lice infesting the external parts of men, quadrupeds and birds but was more inclined to believe with Johann Sperling that they originated from eggs deposited by females.



TAV 24

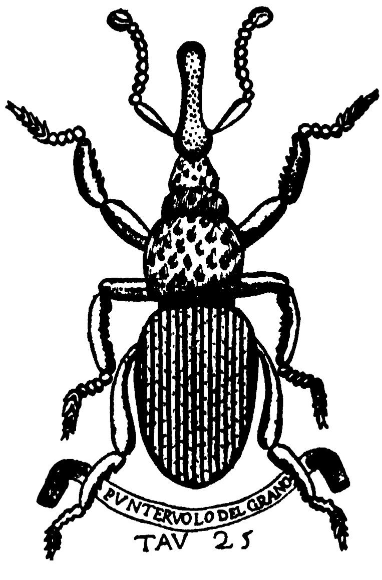
TICK OF THE TIGER

ONE OF THE ILLUSTRATIONS IN REDI'S BOOK. REPRODUCED FROM THE 1909 TRANSLATION OF THE OPEN COURT PUBLISHING COMPANY

Other matters are discussed also by Redi, such as the untrue ideas of bees arising from the decayed flesh of bulls, of wasps and hornets from dead horseflesh and the habits and birth of scorpions. In the course of some of his discussions, he confirms the statements of Galen, Lucian, A. Aphrodisius, U. Aldrovandi and Sperling, that flies die on coming in contact with oil, but could not

substantiate the additional affirmations of Aldrovandi and Sperling that the flies would revive if left in the sun or sprinkled with hot ashes.

Francesco Redi was born in Arezzo, Tuscany, in 1626, some thirty-three years after the emissaries of the inquisition started on the track of Bruno, the Italian philosopher, their activity finally resulting in his imprisonment and death by burning in 1600 for "apostasy, heresy and violation of his monastic vows."



GRAIN WEEVIL

ANOTHER FIGURE IN REDI'S BOOK. REPRODUCED FROM THE 1909 TRANSLATION OF THE OPEN COURT PUBLISHING COMPANY

Seven years after Redi's birth, Galileo was condemned by the Holy Office to imprisonment for an uncertain time on account of his views on astronomy, the consulting theologians of the Holy Office having asserted in 1616 that the theory of the central position of the sun in our solar system and the rotation of the earth were "untrue in philosophy, heretical and contrary to Holy Scripture." Through the intercession of the Duke of Tuscany, Galileo's sentence was commuted to banishment.

Redi in his early youth studied in Florence under the Jesuit Fathers, who were strongly Aristotelian. Then he took up philosophy and medicine at the University of Pisa, later returning to Florence, where he practiced. He finally became court physician and was highly thought of by Ferdinand II, Grand Duke of Tuscany, and by his son and successor, Cosimo III. In addition to his medical duties Redi was entrusted with minor diplomatic matters and often acted as mediator in settling differences of opinion between the Grand Duke and his son. Cosimo, it is recorded, was more interested in prosecuting religious offenders and in settling matters of etiquette than in anything else. In fact, the seventeenth century in Italy, except for the study of nature, has been characterized by some as vacuous, with every kind of affectation and mannered form in vogue. Salvator Rosa, the Neapolitan artist, mourned over the feminality of his countrymen.

On account of his position at court, Redi was sought by the learned of the time and frequently used his favors for the interest of his friends. Filicaja, the poet, was patronized by the Grand Duke, made a senator and later Governor of Volterra and Pisa, while Bellini, the anatomist and physician who studied medicine under Redi, was physician to the Grand Duke. Both were Redi's friends. Redi was a member of the Accademia del Cimento and to this society belonged his friends Carlo Dati, the philologist, who was interested in linguistic purism and to whom his "Experiments on the Generation of Insects" was dedicated, and Borelli, the physicist and astronomer, professor of mathematics in Pisa and later in Messina, from which place he was obliged to move after having taken part in a revolt. Redi was also a member of the Lincei, founded in 1603 by Cesi for the purpose of fostering physical sciences and an Arcadian

under the patronage of Queen Christina, of Sweden.

Redi's attitude toward the Jesuits was always deferential, due perhaps to his early training, perhaps to his position at court where he probably could ill afford to arouse the jealousy of religion by too advanced scientific views. Father Segneri, the Jesuit mission orator, was his close friend, and to Father Kircher he inscribed his report on "Various Natural Curiosities brought from India." In his "Experiments on the Generation of Insects," when disagreeing with Kircher, he speaks of the father as a "man worthy of esteem" being "led into erroneous statements" and of Paracelsus as a charlatan, although at this time the statements of both Kircher and Paracelsus seem equally absurd.

It seems inconceivable that Redi, after confuting the theory of the generation of insects in dead matter and after stating his disbelief in the generation of insects in living matter, should, subsequent to his observations, completely change his mind and attribute the insects in living plants to "the same natural principle that produces the fruits of the plants." Although his entire book is written in a somewhat conciliatory fashion, in his former observations involving dead matter he was not so distrustful of himself. Perhaps his early training and later association with the Jesuit Fathers limited his reasoning when it came to discarding the Aristotelian theory as applied to living matter, a theory embraced by the Jesuits. Perhaps he was unconvinced by his observations. However, the error was later corrected by his pupil Vallisneri. Redi died in Pisa, March 1, 1697, and the many editions of his book indicate that it was well received by coexisting workers. It marked the beginning of experimentation. Spallanzani, born in northern Italy thirty-two years after Redi's death, was inspired by the work to conduct similar trials with microscopic animals, with results similar to those of Redi, thus paving the way for later experimentation and discoveries. A translation of Redi's book on "Generation of Insects" by Mab Bigelow, together with an introduction dealing with his life, by the translator, was published in 1909 by the Open Court Publishing Company.

ARIADNE; OR SCIENCE AND KINDLINESS

By Professor R. D. CARMICHAEL

UNIVERSITY OF ILLINOIS

WHEN Mr. Haldane wanted a quaint figure to stand as a picturesque symbol of the power of science he found it in the great architect and sculptor of Minoan Crete. This Daedalus was a far-distant ancient who was already becoming mythical at the beginning of Greek civilization. Haldane's choice of him may serve to carry the veiled intimation that science has hardly changed its spirit through the ages. It has acquired new power to be sure, it has corrected many of its errors in method and conclusion, it has produced astonishing results, but all through the centuries there have been important problems which it could not undertake, such as the significance of life or the meaning of the universe, or even such as the more imperative one of finding ways to increase kindliness among men.

So great were the known successes of Daedalus, as in the construction of the palace and sanctuary of the Double Axe at Cnossus—a building exhibiting (as shown by rather recent diggings) an extraordinary architectural skill and a remarkable knowledge of sanitary and hydraulic science—and in the creation of the wonderful works of art with which it was decorated, that we are not surprised at the development of those legends which ascribe to him the making of a wooden cow for Pasiphaë and the fashioning of a bronze man to repel the Argonauts.

Daedalus furnishes an apt mythical setting for a picture of science as the benevolent dispenser of great goods arising from increased control over our environment and our material heritage and as the source of blessings which speculation may fancy but experience has not yet known. Indeed the figure appears to be a little too apt for Mr. Haldane's purposes alone. It is quite suitable also for the directly opposed purposes of Mr. Russell, who can not see an attractive future for science but on the contrary says:

> I am compelled to fear that science will be used to promote the power of dominant groups, rather than to make men happy. Icarus, having been taught to fly by his father Daedalus, was destroyed by his own rashness. I fear that the same fate may overtake the populations whom modern men of science have taught to fly.

How far ingenuity might succeed in interpreting the stories of Daedalus as symbolic of science I can not say. But the figure is so apt in one other respect that I can not refrain from pressing it further. In no legend of Daedalus is there an indication of his having contributed directly to the increase of kindliness among men. The nearest approach to something of this sort, so far as I know, is the legend that he made a dancing place for Ariadne, the daughter of King Minos. Partial verification of this legend is found in the fact that such a dancing place has been discovered by A. J. Evans in the Minoan palace at Cnossus. Probably it may be held that the frequent enjoyment of the dance will contribute something to the development of the spirit of kindliness; and evidence to this effect may be offered from legends, since Ariadne afterwards had such sympathy with Theseus as to aid him in avoiding the belly of the Minotaur.

With a little indulgence on the part of the reader and without any more violence to the sacred stories than that done by Mr. Haldane and Mr. Russell I may use the place of Ariadne in the Daedalus legends as symbolic of the position held

by kindliness in the work of science. The resulting essay may be read as a companion to those of Haldane and Russell.[1]

Science has not tended to a study of kindliness. I do not know that any one has so much as raised the question as to whether it is the hormones or the chalones which are its instigators. The hormones are chemical messengers thrown by certain glands into the blood circulation; they serve as excitants and stirrers-up of activities. The chalones are similar but have the opposite function of putting on the brakes. Probably no one knows whether kindliness is a dominant attitude needing hormones to stir it up or whether it is a recessive attitude which will be manifested if the brakes sufficiently retard inhibiting actions or whether both hormones and chalones have nothing to do with it; there seems to be no knowledge of any physiological facts on which kindliness may rest. It is possible that it is not determined by such facts. Science has not tended to a study of kindliness.

And what is much more, science has tended to ignore the presence of kindliness in nature, or at least to give to it only a belated and imperfect recognition. The usual picture of the struggle for existence shows the bared tooth and the reddened claw. There has been a fight to the death where many have passed into everlasting darkness and a few have carried on the light of progress —for a while. As applied to ourselves Huxley has stated this one-sided view in the following words:

> In the case of mankind, the self-assertion, the unscrupulous seizing upon all that can be grasped, the tenacious holding of all that can be kept, which constitute the essence of the struggle for existence, have answered. For his successful progress, as far as the savage state, man has been largely indebted to those qualities which he shares with the ape and the tiger: his exceptional physical organization, his cunning, his sociability, his curiosity, and his imitativeness, his ruthless and ferocious destructiveness when his anger is roused by opposition.

This is the principal direction in which science has tended to look for its understanding of evolution.

But there are other facts, and these lie so closely at hand that it is difficult to see how they were overlooked by so many, or, if seen, were given so little weight. In recent years they have received a fuller recognition. Some of them have been marshalled by the Russian zoologist Kessler to support his thesis that "in the evolution of the organic world—in the progressive modification of organic beings—mutual support among individuals plays a much more important part than their mutual struggle." Geddes has given many examples of the evolutionary rôle of other-regarding activities and of the survival-value of subordinating the self to the species. Drummond has spoken eloquently of the struggle for others as opposed to the struggle for self. Kropotkin has gathered many facts to show the importance of mutual aid in the animal kingdom. To him the law of mutual support is as certain as the law of mutual struggle and is "of the greatest importance for the maintenance of life, the preservation of each species and its further evolution."

It is easy enough to see how the struggle for existence has arisen and why it has survival value. The intimate rôle of mutual aid is profounder and is more difficult to observe. Let us first see how it works and let us then seek its origin.

When baffling difficulties confront an individual he may answer back by girding his loins and throwing himself against the limitations; this is the struggle for existence. But instead of intensifying competition an animal may seek the security and safety of its offspring. A bird may laboriously build more than two thousand feathers into its nest and thus protect its young, unmistakably strengthening the family foothold in the struggle for existence,

[1] J. B. S. Haldane, "Daedalus, or Science and the Future"; Bertrand Russell, "Icarus, or the Future of Science."

but in doing so it is not directly harming any other bird. Instead of sharpening claws and whetting teeth a creature may find a place where their protection is not so much needed. Instead of the fight with kin for subsistence we may have a more elaborate parental care. Instead of the "dismal cockpit" of nature which many have found we see with J. A. Thomson a frequent "endeavor after well-being on a non-competitive basis."

A careless Darwinism has had a sinister effect.

It has given the seeming sanction of science at one time to a soulless commercialism, at another to an overweening pride of race and the lust of dominion. By one of the paradoxes to which the history of thought is prone, the theory of progress has been in the main a weapon in the hands of intellectual and moral reaction. But every new theory has to go through its infantile diseases. The worst of these arises from that distemper of the mind, peculiarly prevalent in the half-educated world of modern thought, which prompts men to pick up ideas which specialists have elaborated for their own purposes in their own departments and apply them indiscriminately as catchwords to settle questions arising in another sphere.

Moreover, there has been "a forgetfulness of the apartness of human society from the animal world with which it is nevertheless solidary—an apartness which forbids any uncriticized transference of a purely biological induction to social affairs." The trend of human society and civilization has been away from the harsher aspects of nature's régime — notwithstanding the terrible temporary lapsings, such as that of the World War. The survival of the fittest among animals should be replaced among men by the survival of those who contribute most to enlarge the heritage which each generation receives from its predecessor and passes on augmented to its successor.

Perhaps it is not far wrong to say that altruistic sentiment has its source in maternal affection. A mother enjoys her children as being flesh of her flesh; receiving pleasure through them she loves them. Parental affection becomes a strong support to the species. The male loves the female, and a psychical bond grows up between them and is strengthened. "The father becomes susceptible to the loved ones whom his mate cherishes. If hers, then his; and their nearness, their helplessness, strengthen the bonds of affection." The antenatal partnership of parent and child creates a bond of close sympathy. "Can any one believe in any origin of altruistic sentiment which does not start from the love of mates, the love of parents for their offspring, the love of offspring for their parents."

The sublimation of sexual attraction into friendship has been one of the great promoters of kindliness both in the race and in the individual. When this has grown into family affection it overflows to kin and afterwards to all men as parts of the common brotherhood of man. Much of the kindliness which has its root in sexual attraction and the care of a family would be lost if relatively few men should be the fathers of half the new generation, each having many children by many mothers—a condition intimated by Russell.

Perhaps it will be agreed that one sex (the female) has predominantly the spirit of kindliness. How much it would help if each individual could have the experience of both sexes, so that everyone would know the kindly feelings of a mother for her offspring. Moreover, the present situation leaves the race in two sex-groups necessarily without the ability to understand each other fully. Whatever blessings the division into sexes may have brought it has certainly left us with the disadvantage of having two groups such that the individuals of neither can enter fully into the experiences of the other. Even in man there is a hint of another condition in which this evil might be removed by a complete hermaphroditism, and this is actually realized in the case of some of the lower organisms. But there is such a revulsion of the normal person from the her-

maphrodite that man can hardly be expected to use this solution of the problem even if he should obtain such control over sex as to produce double-sexed individuals at will.

And yet there can be no doubt that it would contribute greatly to the spirit of kindliness if each one who is a father could also know for himself the experience of being a mother. Perhaps the mothers would also gain something if they might have the experience of a father's cares.

If parents learn to control the sex of their children—as it now seems likely that they will—and if this control results in a large preponderance of males, as Russell supposes, then we must either radically change our conception of the family or leave many men without the opportunity of that development of kindliness which the rearing of a family is capable of producing. If science should lead us to this state of affairs, it would not only fail—as it has in the past—to assist effectively in the growth of kindliness, but it would also be a large factor in destroying for many men their best opportunity to develop kindliness. It can hardly be expected that they would be willing to play the rôle of the sterile worker-bee in the beehive and labor assiduously for the good of the race which they could have no part in propagating. They would become individually harmful and dangerous on the whole to the best growth of human character.

With respect to experiences depending on sex some of the lower animals are more fully equipped than we, though it must be admitted that they have not used their position to advantage. We have already mentioned hermaphroditism which occurs in a true form among some of the lower organisms. It may also be noticed that there are some animal species—the glutinous hag is an example—each individual of which passes first through a stage when it is a male and afterwards through another when it is a female. If they possessed the requisite self-consciousness and memory, they could profit in character formation by the double advantage which we have thought of as coming from being both a father and a mother. They have the physical form without the mental requisite for this value, while we in turn probably have the mental requisite but can not profit by the change of physical function.

We do not yet know in what resides the essential metabolic difference between male and female. One is a sperm-producer, and the other is an egg-producer. Among many creatures, including ourselves, one carries the unborn young and the other does not. The experimental study of sex was late in being developed—due to a certain feeling of indecency about such investigations, a feeling which is often not yet overcome among laymen. But much progress has been made in recent years—as every one must realize who has conceived the vivid picture of ectogenesis drawn by Haldane.

Some investigators think that maleness or femaleness depends on Mendelian factors, and they point in many cases to a special chromosome in the sex cells which they describe as sex-determining in character. Others believe that "sex is an expression of deep differences in the rate and rhythm of metabolism, differences which may be swayed to this side or that by various influences."

When a male crab carries a certain parasitic crustacean called Sacculina its whole constitution is sometimes changed in a remarkable way. It develops female characteristics. The composition of its blood is greatly altered, showing a profound change in metabolism. "The male organ or testis disappears and its place is taken by a little ovarian tissue, which actually produces eggs." There is a change of the abdominal appendages in the direction of the feminine type of the species. "And the

male crab treats the parasite protruding under its tail as if it were a bunch of eggs!" We have been so accustomed to the fixity of sex that we stand almost aghast at such a revelation.

It is known that "the expression of the masculine and feminine characters is in some cases under the control of hormones or chemical messengers which are carried by the blood from the reproductive organs throughout the body, and pull the trigger which brings about the development of an antler or a wattle or a decorative plume or a capacity for vocal and saltatory display." Perhaps it is the effect of parasites on these hormones which leads to the observable results in the conformation and habits of the crab just mentioned.

For some years it has been known that pigeons lay two kinds of eggs differing in the intensity rates of their chemical processes. The eggs which are lower in storage capacity and more intense in metabolism develop into males. The eggs of higher storage capacity and with yolk of greater energy-value develop into females. The differences seen in the two kinds of eggs have their counterparts in the adult birds, as is shown by analyses of the blood of cock and hen pigeons. Professor Oscar Riddle, to whom these discoveries are due, has developed individual birds which one could not call entirely typical of either sex; in each of them there is a sort of blend of the characteristics of both sexes. To some extent he has effected a sort of gradation from one sex toward the other.

More recently such investigations have been carried much further, and we have heard announced the actual change of sex in some individual fowls. We have seen that there are animals with which this is a natural process. But if we are to trust some recent experiments and observations we now have the possibility of changing the sex of some individual fowls in species in which such change does not normally belong to the life cycle. And the scientific study of sex is yet in its early infancy! Though this change of sex in fowls has been claimed, it is yet uncertain whether the results can be accepted. But it is significant of the trend of experiment that the claim has been put forward.

Recent careful study shows that our conscious mental life is affected by influences which flow up from the lower levels of an unconscious stream which moves without ceasing in the deeper recesses of our nature. In these depths lie (1) certain general tendencies and sentiments marking our sympathetic attitude toward mankind, (2) deep racial memories, some of them going back perhaps to prehuman roots, like the almost universal dread of snakes, (3) influences from early life which are now submerged below the surface of our everyday experiences and (4) a deep-seated sex-urge, existent almost from infancy but coming to conscious force only at adolescence and then under the influence of the hormone-producing glands. According to Freud the repression of the sex-urge has a profound effect upon character and conduct which had not been suspected until recent years.

In an essay in "These Eventful Years" (published by the Encyclopedia Britannica Company), volume II, p. 515, Freud himself says:

> But one also came upon another purely empiric result, by discovering that the experiences and conflicts of the first years of childhood play an unsuspectedly important rôle in the development of the individual and leave behind indelible dispositions for the period of pubescence. Thus something was discovered which was hitherto systematically overlooked in science, the *infantile sexuality*, which from the tenderest age begins to manifest itself in physical reactions as well as in psychic attitudes. In order to bring together this infantile sexuality with the so-called normal sexuality of the adult and with abnormal sex-life of perverts the concept sexual had itself need for adjustment and extension, which could be justified by the history of the evolution of the sexual instinct.

It is thus apparent that the present body of knowledge, in biology and in

psychology, has an important fringe in the domain of the investigation of sex—about which we know a great deal without knowing what it is essentially. Both in the discovery of fact and in the development of theory there is great progress to-day in the understanding of sex. It has always been a central factor in human institutions and character and in the conception of ethical and moral standards—so emphatically indeed that the word moral is often used specifically in reference to the rightness of conduct in the sexual relation. The feeling of indecency which many persons experience with reference to the study of sex is already disappearing from the minds of experts, and the layman is becoming used to it in a new way on account of the place which it holds in much of the current literary product—and not least in some of the most widely popular productions.

Many questions of the future center around our increasing knowledge of sex and the effect which this may have upon the future life and progress of mankind. Witness the remarkable intimations of Russell's "Icarus" and the more definite and astonishing predictions of Haldane's "Daedalus." Whether these authors are right in their indications of the possible lines of change makes but little difference. What is important to us is to realize that we are face to face with probable great changes in human society owing to the increasing knowledge of sex and the varying attitude towards it. Probably no one can sense with certainty the direction of change. But that we are to see a world new in many respects can hardly be doubted. Sufficient evidence for this lies in the one fact alone that human parents probably will be able (at a not distant date) to choose the sex of their offspring. We have already considered some of the great consequences which might follow from such a power of control.

With many of these thoughts in mind my head pressed a restless pillow and I had one of the strangest of dreams—but in the dream itself it appeared to be one of the most natural occurrences: we are never surprised at what happens in a dream, however strange it may seem to us afterwards. I appeared to myself to be on the planet Mars and in attendance upon a scientific meeting. To be upon this one of the many islands in our universe appeared no stranger to me than to be upon one of the islands of our earth.

I was present, as I said, at a scientific meeting. The lecturer was giving an address of a semi-popular nature, in character much like those which we frequently have as retiring presidential addresses before the American Association for the Advancement of Science. If I should undertake to classify the speaker I should probably call him a geologist; but the Martian geologists seem to utilize history in their science much more than is possible upon the earth. This is due to the fact that written records seem to be extant with them of such an age as could be described by us only in geological terms. Moreover, it appears that the Martians of to-day have, and have deciphered, the written records of another intelligent race much older than themselves—The Lost Race—a race which has been extinct for such a time as we could describe only in geological terms. The present race of Martians is more like a far-developed evolutionary form of some species of two-sexed individuals such as we have found among the lower organisms on the earth. In my dream it appeared that each individual of the extant Martian race, if he or she comes to full maturity, first passes through the sexually neutral (or nearly neutral) stage of childhood, then through a stage in which "he" is a male and normally a father, then through a sexually resting stage (characterized by a great mental productivity), then through a stage in which "she" is a female and normally a mother, and then finally through a

quiescent stage to death (without any intervening period of senility). The speaker whom I heard in my dream was at the period when one changes from maleness to femaleness.

This Martian historian-geologist spoke to his colleagues as follows:

"It is well known to you that we have for a long time been able to read the picture writing of the Lost Race who preceded ourselves in their dominion over this planet, and that through it we have understood many of their characteristics. It had been suspected that these records, which were deciphered over a century ago, belonged to their earlier history; and, in fact, we have had in our hands for two generations a great wealth of strange documents which clearly showed a later origin both by their apparently more advanced character and by their having been found in strata evidently belonging to a later geologic age. But these strange records remained for us until recently a veritably sealed book. Thanks to recent excavations and to the remarkable skill of contemporary scholars we have come into possession of a key to the records which have been accumulating for a century, and we are now able to unravel the later history of the Lost Race and to understand something of the cause of their disappearance. All of you have heard of the discovery of the remarkable Parallel Document, so called from the fact that we have the same extended account engraved on stone in parallel columns in two systems of writing, one of these being the known picture system and the other being an alphabetic system. With a great skill and ingenuity in linguistic interpretation the former has been made to yield the key to the latter; and the accumulated documents of a century of excavations have become an open book to us. They yield a fascinating account of the later history of the Lost Race and thus give us a new means of understanding by contrast many of our own advantages. I shall undertake to set forth some of the remarkable results of this recent scholarship.

"Let me first recall to your minds briefly the state of our knowledge of the Lost Race prior to this recent decipherment of their later records. As already indicated, this has been drawn principally from the picture-writings—now definitely known to belong to their earlier history. It is natural that our knowledge of them should have arisen from these primitive records, for pictures furnish a universal language. Even in the conventionalized form used by the Lost Race in writing there yet remained something very suggestive of what was intended by the symbols. Notwithstanding this we should probably never have been able to decipher them had it not been for the fact that their scientists had attained to an accurate knowledge of astronomy and geology. There is a certain invariancy in the materials of these sciences over a long period of time. They described geological formations so accurately that we were helped in finding the meaning of many symbols by our own precise knowledge of the facts which were being described. But, most of all in their statement of the precise laws of astronomy, we have had the best means of checking up their picture symbols for things of a more abstract nature. But I need not carry you through this whole story; it is already familiar to you. It is sufficient to our present purpose to remember that we were able to understand the picture writing of the Lost Race principally from two fortunate facts: The pictures, though conventionalized, were often very suggestive of the meaning intended; the picture documents contain accurate scientific accounts of facts and principles which we also know through the labors of our own scientists, and we are thus able (by means of what we know) to successfully interpret their language when they describe or explain the same things.

"From the picture writings and especially from the fragments of biology, we have learned that each individual of the Lost Race was a one-sexed individual like most of the lower animals whom we know to-day. We shall see later that their destruction was intimately connected with this fact. But we must dwell a little while on the fact itself, since it is so hard for us to realize that a really advanced race of intelligent beings could exist when every individual has the experience of only one sex. They were never able to profit, as we always do, from the wisdom of our Old People, each individual of whom has passed through the whole gamut of racial experience. Their population existed in two groups separated by a wide gulf. There could be no passing over from one sex to the other in the experience of a single individual. No member of the Lost Race could have more than half the normal experience of an intelligent individual. One might be a father; but, if so, that one could never be a mother. One might be a mother; but, if so, that one could never be a father. As a result of this every member of the Lost Race came to the end of life with only a half-life's experience, so to speak. Judged from our point of view, every member of that race died in immaturity, without ever having come to a state of quiet and full wisdom such as all our Old People have reached.

"After youth the members of that race passed to a sexually mature stage and in that stage they spent the greater part of their lives. They did not have the sexually resting stage during relative maturity when an individual could be free from those appetites of the body which so often are distracting to mental occupations. One of our greatest blessings, as we all recognize, comes from the achievements of our middle age when we are sexually neutral. Our whole energies then can go into mental activity. This is the period of life, as you know, in which nearly all our greatest scientific discoveries are made. Without such a period we could not maintain our present high state of science and civilization; this proposition would probably be disputed by no one who meditates on the great flowering of mental achievement which we so often witness in the period of rejuvenescence in which we are sexually neutral. But the members of the Lost Race had no such blessings. When they passed from the stage of sexual activity they entered upon a strange period which they called senility. The body remained alive and the mind continued to exist in some imperfect and slowly functioning form. Neither the body nor the mind remained strong to the end, except in the case of very few individuals. They did not possess the means of rejuvenescence which is common to us just after the stage of maleness and prior to the stage of femaleness. These beings, in some respects highly organized and highly endowed, were lacking in that plasticity which is needed if each individual of the race is to pass through what we may call a full racial experience. Each individual of them could have only a half-racial experience.

"This fact concerning them we have known for a long time, and we have realized how it must have left them always with a strangely incomplete experience. The race was divided into two parts, one of them having one portion of the racial experience and the other having another portion; but no individual could have a full racial experience. This, I say, we had known for a long time; but it is only with the recent decipherment of the more advanced documents that we have been able to realize what was implied in this defect. That the Lost Race itself was only dimly aware of its deficiency is natural, for it is well known from the geological record that they flourished at a time when only low forms of life existed with the nature which has since been found essential to the highest

achievements, namely, that in accordance with which each individual passes successively through both sexual stages with the intermediate sexually neutral stage. But when we look upon their newly revealed history from the vantage point of our own experience we have readily such an understanding of them as they themselves could not have acquired.

"A word must be said about the nature of the new documents which have been recently interpreted. As already indicated, they are alphabetic in character. It is remarkable that this ancient Lost Race made in a fairly perfect form such an achievement as this—one which we know ourselves to have made only after a long struggle through numerous tentative written languages. To find a means of interpreting an alphabetic written language is very difficult unless there is some clue to it. This explains why we could have remained in possession of these ancient documents a long time without understanding them. We might never have deciphered them had it not been for the discovery of the remarkable Parallel Document. With the latter in hand, the task became possible, though it was still difficult. The key to the alphabetic language was discovered. Thus the accumulated alphabetic documents became open to us. Once it has become possible to interpret an alphabetic document it can be read with much greater ease, speed and accuracy than a picture document. This accounts for the rapidity with which the alphabetic documents have become known to us, once a key to them had been discovered.

"As intimated, we are now in a position to understand the disappearance of the Lost Race. I have singled out this aspect of our knowledge of them for special emphasis at this time because of the great lesson which it has for us. I need not pause to speculate on what would have been the consequences to ourselves if the Lost Race had not perished. But I may, in passing, point out one obvious fact. If that race had not disappeared there would have been no place for us. As it turned out, they lacked stability, to be sure; but they were on the scene ahead of us. One of their scientists has described a small animal which we recognize as our remote evolutionary ancestor; and he described that animal as an undoubted lower organism. Moreover, our ancestor was evidently repulsive to him, for he speaks, almost as with a feeling of indecency, of the fact that each individual in the race of our ancestors passed in its life through both sexes. There can be no doubt that the Lost Race, if it had remained in its one-time position of supremacy, would have resented the evolutionary emergence of our race and would most likely have destroyed our ancestors. It raises strange feelings in our mind when we realize that our present state and probably our very existence depend on the fact that the Lost Race did indeed disappear. With what feelings would the members of that remote race have contemplated our ancestors if they could have suspected that they themselves would later yield their supremacy and disappear while we ourselves should come to such heights of achievement as they were never able to reach.

"But we must return to a consideration of the fatal weakness of the Lost Race. This was revealed only when we began to interpret the more recent records of their experience. In this way we have been able to understand what was formerly a great enigma to our best scholars. Heretofore we had known but little more than the material surroundings and conditions of the Lost Race. While we saw many of their imperfections as compared with ourselves—some of them I have already mentioned—we nevertheless found them in possession of a harmoniously organized body and in control of material forces far beyond the minimum that would be necessary for

subsistence at a high level. In none of these things was there any intimation of the prospective doom awaiting them. Our best thinkers had long felt that there was nothing in the material or physical situation which could account for the disappearance of a mighty race with sound bodies. It had been suspected that something in mental outlook or moral standard—in short, something of a spiritual character—stood between them and that perpetual dominion on our planet to which they looked forward —apparently not without cause.

"That this suspicion of our scholars was correct has now been abundantly verified by the conclusions which are inevitable from the facts found in the recently deciphered documents. But the specific nature of the defect which has been revealed is such as no one could have suspected as belonging to rational beings—in fact, it is so strange as to raise serious doubts as to whether the members of the Lost Race were really rational beings.

"Let us see what were some of the facts in the case. They continued to be warriors up to the end, that is to say, as long as they existed in sufficient numbers. In the primitive ages of their earliest history war was probably useful in developing some of the ruder of the sturdy virtues and in its selective effect; this is in accordance with what is generally recognized in the remote history of our own race before war was abolished. But there came a time with them when war was no longer profitable; it was merely destructive. In this respect it was like what our own historians tell us about our remote past. It appears that all the advantages of war are reversed and become evils when the race engaging in it has become possessed of a sufficiently full control of material resources. It becomes possible for a few well-equipped persons to destroy too great a number of his opponents; it gives no opportunity for developing those ruder rugged virtues which primitive conflict seems to have a means of fostering; it exercises in no way a selective influence but destroys the population without discrimination even to the extent of wiping out whole cities and provinces.

"Such is the experience through which the Lost Race passed. Wars continued with them without ceasing, as we learn from the remarkable document prepared by some of the last remnants of the race on the remote island of Enola—an island on which excavations have only recently been made. If the great so-called Last Document of the Enola remnants of that race is not indeed the last record which the race has left us of their experience it is certainly not far from the last. This remnant contained the sole surviving members of the Lost Race which they themselves knew; and they probably came to their end from earthquake or other great disturbance of the island, for the island of Enola is known to have been subject to volcanic action.

"But let us return to the record which the Enolans have left of the later history of their race. It is principally an account of wars which increased in ferocity from generation to generation. For some thousands of years these wars were in the nature of combats confined to certain parts alone of the planet. But with increasing organization and control of materials and means of transport these became broader in their reach until each of them finally involved the whole world. The means of combat were so cruelly refined and the rivalry was so ferocious that it finally came about that the victors exterminated their opponents practically in toto. Many of these people began to feel that life was hardly worth living and the birth-rate accordingly declined.

"Moreover, the victorious members of the Lost Race, having almost completely exterminated their rivals, failed to be able to continue in agreement among

themselves. They became divided into hostile camps and fought to the practical extermination of one party. The process was repeated through several wars until respect for life had passed to a lower ebb apparently than has otherwise been known among the species of this planet.

"It seems that the continued state of turmoil and the repeated experience of warfare brought about the production of monsters—members of the Lost Race from the lower levels of society who had learned the means of destruction invented by their greatest scientists; and that these monsters, with a diabolical delight, turned the tools of destruction against their fellows and hastened the disappearance of the race.

"From the Enolan records it appears that some members of the Lost Race—at least some of those on Enola—realized the need of a moral awakening, a stirring of a sense of kindliness—which was surely absent from those who planned or permitted these destructive wars. I can not go into the details of the record—in fact, not all of it has yet been deciphered. It must suffice to say that no successful means was found—at least none was found soon enough—to overcome the spirit of rivalry and to replace it with such a spirit of kindliness as would leave the members of the Lost Race with the ability to live together in peace. Obviously they might have continued indefinitely in the state of warfare if they had not developed such means of destruction; but, with the latter in their power and with an unabated spirit of rivalry everywhere rampant, it was inevitable that they should be reduced at least to a few greatly hampered remnants.

"In fact, it appears, as we have said, that they were reduced to the single remnant on the island of Enola. In the writings of these we begin to find a fairly intelligent discussion of the need of kindliness as an element of character. In the earlier records of the Lost Race one can hardly find an intelligible mention of kindliness; and, when there is a reference to it, it seems to be referred to rather as a weakness than a virtue—rather as a confession of inability to hold one's own and a hope that one will be left undisturbed by the more powerful.

"But a certain incipient spirit of kindliness was in existence among the Enolans. They could not fail to see how its absence had brought about the almost complete destruction of their race. But they seem never to have had a realization of the extreme irrationality of a character which possessed great power over the forces of nature but which had not a corresponding great kindliness in its make-up. They got only so far as to sense dimly what the spirit of kindliness must be to be effective for good; and then they disappeared—destroyed, it seems, by the power of the natural elements.

"It will bring strange feelings to any of us to contemplate what might have been the consequences if the Enolans had lived and had rapidly developed a spirit of kindliness and had thus acquired the means of survival in large numbers. They would doubtless then have repeopled our planet, and they would not have permitted our own evolutionary emergence. But they were not to succeed with their too late experiment. They had had their day and chance and had failed; nature would not allow them another opportunity. The Enolans were the last remnant of their kind and the race disappeared with them.

"What is to us the practical lesson of this diagnosis? We should have a new sense of the importance to ourselves of the spirit of kindliness, a characteristic in which we have taken delight for ages. Let us recognize anew its great importance to our evolutionary progress; and,

while we have made such conquest in this direction as has not otherwise been witnessed on our planet, let us resolve that the measure of our kindliness shall always increase. For many ages it has been the greatest theme of our literary people (with the Lost Race a similar place was held by the spirit of competition and rivalry). The choicest gems enshrined in our language were written in praise of kindliness, the authors experiencing a sort of divine afflatus when speaking of it which no other theme has evoked. In the more primitive period of our existence this element of our character was not apparent; but that was the time when our remote ancestors had not yet attained the full standard of rational beings. As we see the matter now, kindliness is necessary in any being of sound character and rational intellect.

"But we must not judge harshly the members of the Lost Race for their failure to develop kindliness. This grace of character is based partly on mutual understanding—and that is a thing which was impossible to them in fulness because of the fact that the race existed in two sexes with a bar between them which could not be passed by any individual. Perhaps their physical constitution made it impossible for them to develop some of the essential spiritual graces. It might be supposed that the mind would rise superior to the physical organism and so emphatically assert the need of kindliness that it would be developed. But such was not the case—at least, it did not happen soon enough to save the Lost Race. They perished from the face of the planet and left the opportunity to us. Will we be able to hold the dominion permanently or is there now some lower organism developing in the direction to become our superiors? And will some later geologic epoch witness their control as the lords of this creation? No one can tell."

This vivid description of the passing of a Lost Race of great power and high intelligence—compressed as it was into a short lecture, and lacking in detail—made a profound impression on the speaker's colleagues. It was clear that they were deeply moved by the conception of the rising and passing of great races; their minds were stirred with profound questionings, inquiring, "What shall we do to be saved?"

As I said at the outset the incidents of the dream, as they were occurring, appeared to be perfectly natural. There was no sense of surprise. When I awaked it seemed almost as if I had been instructed by a supernatural visitor. But I soon realized that nothing had happened except that my mind, uncontrolled in sleep, had put together in a new form the facts that I had been contemplating during the evening, had transferred them to a new setting, and had added a few exaggerated features of its own. I observed that the dream-speaker had assumed without question that mechanistic or materialistic philosophy of life which is prevalent with a certain group of scientists in our own day. When he thought of superior elements of character in his own race he turned without question to seek a physical basis for them. Nowhere throughout his discourse was there more than a bare reference to the possibility of achieving good things through experiences initiated by the mind.

It was not difficult to agree with him about the beauty and worth of kindliness, but I could see no good reason for supposing that it rests entirely or even mainly on the physical basis which he urged. That there would be a certain advantage arising from the rôle of sex in his race and from the activities of the sexually neutral period I could well believe. But I could see no reason for giving it the central position which he assigned to it. Nevertheless, it set me on a curious speculation which I shall record.

It is evident that the two sexes of the human race have developed distinctive qualities of character, and it is conceivable that an advantage might arise if we had means of producing in every one the better qualities of both sexes. In order to bring this about it is important to know the cause of these qualities in the two sexes. They arose in the evolutionary process. On the physical basis let us suppose that these qualities are brought out in an individual by hormones which are sent out from the sex-glands, the process of evolution—so far as this matter is concerned—having procured the selection of individuals in whom the hormones are generated. If the differences arise in this way, the sexes could perhaps be brought toward a common character by a transfer of hormones from each sex to the other. This is a weird speculation which the Martian theory of sex suggested.

The restrained insistence of the Martian on the need of the spirit of kindliness is much more impressive. His Lost Race, of course, was only the dream picture of our own race—a race with too much power in its hands for the measure of kindliness which it possesses. We must always face the possibility of losing our dominion over the earth and having our place taken by other evolutionary forms developing into beings of higher survival value. We have not always been the dominant creatures of this earth. Several different masters ruled before we appeared on the scene. Will others rule after we have become extinct? No one can say. I believe that we are in no imminent danger of immediate destruction. But it does begin to appear that we need a newer and finer spirit of kindliness than we have yet developed if we are to secure the continuance of the present dominant civilization.

Science has not done the work of developing a spirit of kindliness to the requisite degree. Neither have our divines nor our ethical philosophers made sufficient progress in this direction. Neither has the life and work of man as a whole. In his "Icarus" Russell draws a terrible picture of our progress towards stability and a living condition. Without more kindliness a trend in the direction of rivalry and suppression, as indicated by him, seems likely if not inevitable. We are headed in that direction now, probably on account of the philosophy of life that we hold; and the philosophy which this generation holds is that which science has taught it.

Now science appears to have been one-sided in its development. The fact has been pointed out before, but apparently the warning involved in it has not been sufficiently heeded. I want to reiterate that warning with the hope of turning more attention to it. To develop the neglected side of truth holds out a hope to us, especially as it is the side of truth which pertains to character and human aspirations. I can not present the warning to better advantage than to quote the utterance of the great James Clerk Maxwell.[2] Maxwell says:

> In all such cases [as those which he had just described] there is one common circumstance—the system has a quantity of potential energy, which is capable of being transformed into motion, but which can not begin to be so transformed till the system has reached a certain configuration, to attain which requires an expenditure of work, which in certain cases may be infinitesimally small, and in general bears no definite proportion to the energy developed in consequence thereof. For example, the rock loosed by frost and balanced on a singular point of the mountain side, the little spark which kindles the great forest, the little word which sets the world a fighting, the little scruple which prevents a man from doing his will, the little spore which blights all the potatoes, the little gemmule which makes us philosophers or idiots. Every existence above

[2] See the discussion of determinism and free will in "The Life of James Clerk Maxwell," by Campbell and Garnett, pp. 434–444, quoted in Henderson's "Order of Nature," pp. 213–228.

a certain rank has its singular points: the higher the rank, the more of them. At these points, influences whose physical magnitude is too small to be taken account of by a finite being, may produce results of the greatest importance. . . .

It appears then that in our own nature there are more singular points—where prediction, except from absolutely perfect data, and guided by the omniscience of contingency, becomes impossible—than there are in any lower organization. But singular points are by their very nature isolated, and form no appreciable fraction of the continuous course of our existence. Hence predictions of human conduct may be made in many cases. First, with respect to those who have no character at all, especially when considered in crowds, after the statistical method. Second, with respect to individuals of confirmed character, with respect to actions of the kind for which their character is confirmed.

If, therefore, those cultivators of physical science from whom the intelligent public deduce their conception of the physicist, and whose style is recognized as marking with a scientific stamp the doctrines they promulgate, are led in pursuit of the arcana of science to the study of the singularities and instabilities, rather than the continuities and stabilities of things, the promotion of natural knowledge may tend to remove that prejudice in favour of determinism which seems to arise from assuming that the physical science of the future is a mere magnified image of that of the past.

Though much could be said in favor of the thesis implicit in this statement by Maxwell we shall pass over it rapidly. It can not be doubted that science has left out of account nearly all that pertains to one side of the human picture. As Maxwell says, it has given itself almost entirely to the continuities and stabilities of things and has neglected the singularities and instabilities. It may be that the latter are not subject to its method: it is certain that they have not been adequately treated. There seems little doubt that it is just this defect in science which has made it so impotent in the matter of human character: it can contribute but little directly to the establishment of the profounder virtues. It has great power and control with regard to material things, but it is still essentially without direct force in enhancing moral standards and enlarging moral values.

This generation must live now principally with the heritage which science and human experience have already brought to it. With no apparent purpose of science to turn in the direction of investigating the discontinuities and instabilities of things, we must get along without the assistance which such study might render—help in the direction of developing desirable traits of character. The material means now in the control of science offer little hope of being of direct use in developing character. The stimulation of hormone production, or even the transference of hormones, is wholly inadequate to the task. There are no means at present under the control of science by which the needful spirit of kindliness may be engendered or increased.

In the face of this fact one may be inclined to pessimism and conclude that there is nothing that we can do to change the trend of evolutionary progress. If we are tending now to follow the experience of the Lost Race of Mars there is nothing which science can do to develop new traits of character to keep us from the inevitable end.

Though we admit the inherent danger in our present situation and realize keenly the need of a greater spirit of kindliness, we do not believe that this pessimistic conclusion is yet inevitable. We should still maintain this position even though we should be convinced both that science has no present means of acting directly for building human character and that there is no prospect that science shall find such means. We believe that there are pathways to reality which science not only has not trodden but can not even find—at least, that there are avenues to truth which can not be approached by the methods to which science has attained. If new methods are found and they are incorporated into science, then of course the renewed

science may achieve such conquests as are now impossible to it. But we believe that there are pathways to reality which science can not now follow.

It is along some of these lines that we must expect our present salvation. No amount of psychobiology or of biochemistry—good as these are as aids—can carry us to the goal. I shall be so radical as to insist that we are in need of the old-fashioned practice of meditating upon the nature of human character and of considering what sort of individuals we must be if life is to be worth living. We must understand life by living it and by meditating upon its problems. There is no doubt that our reasoned interpretations of experience and our reasoned analysis of needs are in advance of our primitive inclinations. Is it demanding too much of what appears to be a rational creature to ask him to meditate upon his reasoned conclusions so fully and so deeply that he will be able to give them a place in conduct in preference to the primitive inclinations which he has inherited from his savage or even from his prehuman ancestors?

In our dispositions these primitive elements still hold great sway, and they will certainly rule unless they are controlled by something more powerful. The urge to competition and rivalry is deep-seated in our nature. But if we see clearly, on reasoned analysis, that this is taking us towards the destruction of what we hold dear, then we should be able to create in ourselves a power sufficient to overcome this urge to rivalry. And this we can probably do by much meditation on our reasoned conclusions and on the values which make life worth while. Let us develop a will to kindliness. Is it too much to hope that such a thing is possible?

There is no reason to think that all men, or even the majority of men, will realize the need of kindliness so fully as to turn to its cultivation. Many will think it impossible. Can the leopard change his spots? Can one by taking thought add to his stature? Can one seize on the unstable moments of life and turn the scale of character by taking thought? A mechanistic or deterministic science has thundered, No; and No has resounded over the earth. Perhaps man is pitiable and helpless and destined to destruction by the powerful tools of science which he has created and loosed upon himself. A significant part of the present generation has already gone in that way. Another prolonged world war would carry off a much larger portion of the whole population without discrimination of age or sex or condition. The only salvation from it is the cultivation of a widespread spirit of kindliness and cooperation. And neither science nor ethics has found a way to foster it. Are we destined to perish like the Lost Race of Martians in the dream and leave the heritage of the earth to another race more kindly or less powerful than ourselves? Or, perhaps sadder yet, shall we allow our present civilization to perish and leave the earth to a degenerate race of men still without kindliness but also without the ability to produce the destructive tools of science? Unless the will to kindliness springs up among us in new power, we are in danger of one of these alternatives.

RACE AND PSYCHOLOGY

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YOU say of this man that he is as witty as an Irishman, of another you murmur that he is as canny as a Scotchman, while a third one is as stoical as any Indian. And if still another certainly knows the retrieving possibilities of the American dollar he will be, in nine cases out of ten, say, a Hebrew. He might be a Hebrew of the Hebrews. Now again keep in mind the "fine Italian hand," while I call attention to the fact that a sixth is as easy-going and communicative as a real Negro unless, of course, he is as industrious and deeply silent as a "Chink."

Just now there is a great deal of discussion of this kind of thing. The psychologists who are only partly in on the discussion are accustomed to call it by the name of "Racial differences in mental traits." If one listens in on the debate one would surmise that there is much disagreement among the individuals engaged in the discussion. And so there is in fact.

The debaters divide themselves into two camps, as a matter of course. The members of one of these proceed on the assumption that there are really such racial differences, while the others insist that this assumption is taken without due evidence on which to base the assumption. The first group may yet be divided into two other groups—one basing its conclusions either on merely traditional notions of race or on more or less superficial, concrete somatic, or bodily dissimilarities and cultural differences that may be actually observed, and for that matter upon pure race prejudice; while the other either observes in a more or less careful way the facts of language, history, custom, racial accomplishment according to some standard, or they may even make a scientific examination of these. We note here the divisions of individuals as casual observers and scientific students. These divisions of individuals are likewise found in the other or opposing camp composed of those refusing to accept the evidence so far obtained as conclusive. Many members of this latter group grant the possibility and even the probability of differences and if convinced would certainly take a stand for the affirmative, being partially convinced by evidence not altogether convincing.

In this day, when the scientific method is the accepted method of procedure in all lines of investigation, little need be said in favor of the standpoint of the above-mentioned scientific groups which look thus to ascertaining the facts about race and psychology. However, we ought to examine the approximations to a scientific standpoint before throwing them into the discard. All sciences of a social character, especially psychological science and that is our final standpoint here, must be "cosmopolitan" toward the beliefs of men of the world. Psychology must be sympathetic at least toward all mental states, as it were tactful, because it is supposed to know and to understand just why men think as they do, for it deals with the very laws of mental life. An intolerant psychologist would be a misnomer. At any rate, it would be interesting to try to find out, if time only permitted, why race prejudice is the rule and not the exception among the general run of people, why it is the "popular" state of mind, of course granting that popular opinion is the most unscientific way of looking at

things. To be brief, it is safe to say that race prejudice is the outcome, and a natural outcome, of the mind itself, if for no other reason than this—so many are afflicted with it. Moreover, there may just be some biological reason (psycho-biological) for the prejudice. At least it takes heroic resolution and will-power to overcome it, and it is gratifying to think that in the face of such resolution it grows weaker.

The foregoing remarks bring up for consideration, on the other hand, an unpopular attitude of mind not usually called scientific that holds the opposite view, decidedly, from that of race prejudice. Curtis says that Hiamovi, chief among the Cheyenne and Dakota Indians, has expressed this attitude of mind in these words:

> There are birds of many colors—red, blue, green, yellow—yet all one bird. There are horses of many colors—brown, black, yellow, white—yet all one horse. So, cattle; so all living things—animals, flowers, trees. So men: in this land where once were only Indians are now men of every color—white, black, yellow, red—yet all one people.

Likewise we have: "There is neither Greek nor Jew, Barbarian, Scythian, bond nor free," with its religious connotation.

In justice to the immediately foregoing paragraphs we may say that these attitudes of mind which we have designated as "popular and unpopular" long ago had taken up the problem which science and near-science have undertaken to solve to-day.

But in its last analysis the problem of racial differences in mental traits resolves itself into the task of proving empirically differences in native traits, and we desire to place the emphasis here on the terms "empirically" and "native." It must be remembered that until psychology became an experimental science it could not really claim any fellowship with the sciences, and so in the study of racial differences, unless we are going to give over the ground already gained, the problem here in hand must be an empirical one. Again, racial mental differences to be really racial must be differences on account of innate tendencies laid down in different kinds of germ plasm. They can not be due to differences in training and education.

Many writers, in the absence of empirical evidence, have indulged in theorizing. Still this theorizing has been helpful in the main, though it was theorizing and not experimentation, for it has somewhat made clear the problem and it has in fact enabled the experimenter to approach it more intelligently.

We shall present now some of the theoretical conclusions based on observation not really empirical. We can not give many because of lack of space and for that reason have selected rather representative samples. The first is rather striking.

"To speak of the stability or the psychological fatality of peoples," says Jean Finot, "is like one who would make believe that circles caused on the surface of the water by a falling stone retain their shape forever—the science of inequality is emphatically a science of white people. It is they who have invented it and set it going, who have maintained, cherished and propagated it, thanks to their observations and deductions. Deeming themselves greater than men of other colors, they have elevated into superior qualities all the traits which are peculiar to themselves, commencing with whiteness of the skin and pliancy of the hair. But nothing proves these vaunted traits are traits of superiority—the history of civilization is only a come and go of people and races—all people evolve under the influence of external factors; consequently, there are none predestined beforehand to be the masters or slaves of others, as there are none who are predestined to an eternal immobility! Virtue and vice in peoples are only the product of circumstances. Civilization, which intends to increase

and equalize the number of those which act in a uniform way towards all peoples, produces as direct results the increase of their similarities and the levelling of their differences.'' In the course of his discussion, he speaks of the triumph of the milieu (environment) and the failure of the psychology of peoples.

Surely the reader will be aware of the immoderation of the writer; still to our way of thinking his point on the mobility of the races is a very important one if his language is ''colorful.''

As an advocate of differences in mental traits of peoples we quote from Gustave Le Bon in his book, ''The Psychology of Peoples'':

> The point that has remained most clearly fixed in my mind, after long journeys through the most varied countries, is that each people possesses a mental constitution which is the source of its sentiments, thoughts, institutions, beliefs and arts . . . . These are but the visible expressions of its invisible soul. The dream of equality would perhaps avail as much as the old illusions which cradled us in the past, were it not that it is destined to be shattered at an early date on the immovable rock of inequalities. Each race possesses a mental constitution as unvarying as its anatomical constitution. There seems to be no doubt that the former corresponds to a certain special structure of the brain, but as science is not sufficiently advanced as yet to acquaint us with its structure, we can not have recourse to it as a basis of classification.

The contentions of this writer may thus be summarized: Races have souls varying within certain limits; are arranged in hierarchies—as primitive, inferior, average and superior; have mental attitudes which are responsible for their institutions; experience such modification as is responsible for the historical evolution of the single race.

If we take these two presentations of the opposite sides of the extremely theoretical treatment of the situation with regard to racial mental differences, we find the essential points of disagreement to be just these: one believes that races are mobile (Finot), and the other believes that they are static (Le Bon). Both would seem to agree that differences are to be found, but one, the former, holds that these are only temporary, and the latter that they are permanent differences.

This seems to the writer to be the greatest problem that we have in hand: if there are differences, are they transitory or permanent? But we mean to think only of innate differences which may be taking some liberties with the intentions of the above-mentioned writers. We shall speak of this at length later. But we now cite the opinion of Sir Francis Galton, the pioneer in the study of racial differences who is certainly to be regarded as scientific, though this expressed opinion must of necessity be speculative. It was Galton's very definite conviction that there are differences to be found in the mentality of races of to-day. For instance, he thought that the Athenian Greeks were as far above the present-day Europeans as these are above Negroes. He accounts for the fall of the Greek intelligence on the scale to its lowest level to amalgamation with less intelligent peoples. The superior Athenian Greek is to be regarded as the result of inbreeding of superior individuals from the Mediterranean countries, Grecian as well as otherwise, regardless of race. The present Grecian product is to be looked upon as a result of outbreeding, in which all classes, whether low or high, intellectually, participated indiscriminately. Beyond a doubt this may be considered an argument in favor of mobility of races as a concept of genetics.

We would cite next a statement of Wilhelm Wundt, the father of experimental psychology, as found in his ''Elements of Folk Psychology,'' which, while given with an experimentally scientific background, is of necessity theoretical. He says:

> The intelligence of primitive man is indeed restricted to a narrow sphere of activity. Within this sphere, however, his intelligence is

not noticeably inferior to that of civilized man. His morality is dependent upon the environment in which he lives.

Here again we find "the triumph of the milieu" as indicated by Finot. The point is further emphasized by Wundt when he speaks of stages of development of the different races and in which he positively believes, but these as products of environment, especially the social media of language, customs and religion.

In order to agree with Wundt we should have to accept the statement that primitive minds are undeveloped minds only and that civilized minds are only nurtured minds, and that the "mind" or brain is a static thing at least within the limits of history. Its original nature is constant, but nurture has modified this original nature in the life of each single individual. Because of the prestige of this writer this may be tempting us away from the original problem to be considered, *i.e.*, innate differences in mental traits. We do not believe that Wundt, if we read closely his discourse, means at all to imply that brains might not be changed by inbreeding and outbreeding.

One of our leading anthropologists, Professor Franz Boas, is often cited as favoring the last-mentioned view, that is, the "innate equality of races." But according to Lowie, a more careful examination of his standpoint shows that he believes in "plasticity within strict limits and claims that all the essential traits of man are due primarily to heredity."

It is now in order to say that such prominent geneticists as are represented by Professor Conklin, of Princeton, would teach that races are not static as biological groups but change by inbreeding and outbreeding, which processes are induced by the presence or the absence of barriers geographical or otherwise.

Our examination of the problem so far leads us to think of races as not necessarily static mentally, but of races as possibly mobile, some rising, some falling, some trying to remain static but finding it difficult. To resort to Finot's "colorful" language once more: races are like "circles caused on the surface of the water. The character of a people is thus only a becoming. The qualities of our soul and its aspiration are fleeting, like clouds driven by the winds."

This all sounds poetic, but we can not resist pointing to a scientific principle underlying the whole thing, to wit, the principles of genetics especially in the light of the facts of inbreeding and outbreeding. And the pragmatic side of the problem is the improvement of what we have by the means of eugenics through education. No intelligent member of any race should stand for race equilibrium, but for race progress.

Racial psychology is sometimes called mental anthropology, and the anthropologist has a rightful interest in the matter, however scientific procedure, and that is what we now need to discuss, in this field of investigation, calls for the activity of the experimental psychologist who is continually measuring mental processes in one way or another. Interest in the field of racial difference in mental traits, therefore, has induced the scientific psychologist to come out of his laboratory with his technique and measure mental processes of various races. In order to feel that his work has been sufficiently far-reaching he must measure large numbers of a given race, and this need has given rise to the use of group mental tests in distinction from the slow individual tests formerly used. While there has been much discussion of the virtues of intelligence tests by laymen, educationalists and scientific psychologists there can be no doubt in the mind of the last mentioned that they have come to stay. To-day the question is not, shall they be discarded, but how to improve what we have. So with the group mental tests the psychologist is rather vigorously attacking the problem of racial difference in mentality.

It is interesting to note that in the last eight years peoples of all colors have been thus studied and the work is going on. Because of their easy access Negroes in America have been more studied than any other racial sub-group; however, the black man in Africa has been studied as well. The American Indian has been willing to submit himself to mental measurement. Tests standardized in America have been translated into the language of Chinese and Japanese and given by psychologists of those races to many of their fellow-countrymen in their own country and these races have been studied on American soil. At this moment students of racial psychology may be found administering intelligence and psychological tests of various sorts in Hawaii, in Australia, in the Philippines and in India as well as in China and Japan. Immigrant and native born of immigrant parentage have been much studied in America. In the last eight years, 5,873 American Negroes, omitting those of the army draft tested with the Army Alpha, 2,032 American Indians, 1,245 Chinese, 596 Japanese and 753 Mexicans have been tested.

As every one knows, the French psychologist, Alfred Binet, devised some time ago an individual intelligence test. This was followed by the group intelligence tests, particularly the army tests which test large groups at once. Since then most of all testing as above indicated has been done in groups and for the purpose of testing intelligence. Those studying race psychology have followed this lead, and most of the studies in racial psychology, especially in the last decade, have been on groups with the end in view of finding differences in intelligence. However, there are other traits besides intelligence to be studied, such as racial temperament, musical capacity, esthetics, memory process, fatiguability, ingenuity, and learning; not but what some of these traits are believed to enter into the general concept of intelligence. If we may call tests for these latter traits just "psychological tests" we can say that in the last eight years the ratio between activity in giving the two sorts of tests, intelligence and psychological (meaning by the latter tests in esthetics, temperament, fatigue, etc.) is three to one in favor of the search for differences in intelligence.

The last four years have marked the period of greatest activity known to race psychology. For instance, from 1917 to 1920 inclusive fifteen studies of all sorts were made (on Negroes, in America and Africa, the American Indian, Chinese, Hindus) but from 1921 to 1924 inclusive sixty-one studies (on the above-mentioned races and others besides) were made.

Since the method used in making these studies is avowedly scientific the results must of necessity clear up a great deal that has been hazy with reference to ideas of racial differences in mental traits. True the measuring devices are not perfect; still some valuable information is being gained. It would be interesting to note some of the findings so far obtained. In the studies of intelligence, then, if we take the average white man's intelligent quotient (his I. Q.) as 100, these investigations show that the average Chinese I. Q. so far found is around 98 and 99. The Japanese are about the same, 98. The American Negro's I. Q. is about 75; that of the northern being much better than that of the southern Negro. The Mexican I. Q. seem to be around 89 (but the group tested was small).

Because of language difficulty and difference in social status from the whites the approximate I. Q. for the American Indian seems to be still in doubt, but the mixed blood Indian was found to be somewhat more intelligent than the average Mexican or full blood Indian.

So much for the racial differences in intelligence. The results can not be taken as final, but they are interesting.

The fact must not be overlooked that in each racial group mentioned there are some individuals with high I. Q.'s, regardless of their race. For instance, it is interesting to note an occasional I. Q. of 135 among full blood Indians. Though the white race has many I. Q.'s higher than those of most of the colored races, no race has lower I. Q.'s than it. They all grovel in the dust of idiocy at the lower end of the intelligence scale, white, black, red men or yellow. Feeble-mindedness is no respecter of races.

As to the results of the psychological tests it may be said that these show, using white norms as bases of comparison (though the returns are not very far-reaching because of the small groups studied) interesting comparisons: In esthetics Indians are found to prefer the color red to all other colors, while whites prefer blue above all colors. Education of the Indian induces him to place blue first in preference, though he still holds red in high esteem. Not so with the white, whose education induces him to despise red more and more as he becomes educated; and not only is this true of his regard for that bright color, for he, in fact, in contrast with the Indian, suppresses all liking for colors with increase of education, with the exception of blue, which maintains its high esteem always. In mental fatigue the Plains Indians are able to hold out better than the whites or Negroes or even the Plateau Indian and the mixed blood Indian. The Negro is good in memory at first, but loses as he grows older. He learns less rapidly. His personality is not as strong as that of the white. The Chinaman in a morality test was found to be more honest than Anglo-Saxons or Japanese taking the same test.

It has been said that the white man's intelligence tests are not fair to peoples speaking a foreign language and having different customs, unless exact equivalents can be found for them; and, what is more, some investigators claim that difference in social status of peoples in the same country, as in the case of Negroes or Indians or whites, may make a difference. For this reason, possibly the so-called psychological test is being used more than formerly, for here the aforesaid differences in opportunity seem to operate less freely.

However, regardless of what we have just said, it would appear that the results obtained show tendencies that are significant and we have to conclude that these tend to be real differences, though they may be at present only roughly measured.

Now the last point is this. If we believe in the mobility of races at least in a direction from the lower end of the scale to the higher, from inferiority to superiority, in mental traits, it behooves any race to look to the eugenics of the situation. By outbreeding a race may scatter inferiority indiscriminately among its future members; by inbreeding and selection for propagation of those regarded as superior it can move its average up toward relative superiority. This of course is made possible only if a race contains any superior members.

LABORATORY METHODS OF ANALYZING SPECTRA, WITH APPLICATIONS TO ATOMIC STRUCTURE[1]

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A SPECTRUM, in its broader sense, is to be considered as the analysis into its component frequencies of any sort of radiant energy, and in the scope of our modern knowledge it becomes a very inclusive term. For the range of frequencies to be considered may begin with the gamma rays of radium, pass through X-rays, the ultra-violet, our visible light, heat rays beyond the red and the radiation of electric waves up to the radio waves several hundred meters long. A given source of radiation, however, usually gives out frequencies extending over only a part of this possible range. Radio waves do not emit light or sensible heat. Bodies may be hot without giving out light. Our bright electric arcs are not efficient sources of X-rays. So I will limit my talk this evening to the range of our visible light, with short extensions into the ultra-violet and infra-red, and speak of a very few of the problems in this field.

Early studies of the spectrum were concerned chiefly with spectrum analysis, the identification of the chemical elements by means of their spectra. As this is the only means of finding out the composition of the sun and stars, the requirements of astronomy have played a large part in developing apparatus and methods of studying the spectrum. On the astronomical side, the elements composing the celestial bodies are now for the most part well determined, and comparatively little in spectrum analysis, strictly speaking, remains to be done. A few lines in solar and stellar spectra have not yet been assigned to known elements, but they are probably in most cases due to compounds or to radiating conditions which we have not yet imitated in the laboratory. On the laboratory side, very extensive tables of wavelengths are available for the spectra of known elements. Identification of the elements by this means is a simple matter, and spectrum analysis may be made quantitative to a certain degree and used as a means of determining the amount of a given substance when mixed with others. This application may be of much value in industry.

However, while the spectrum was being used to identify chemical elements, some features became evident which form the basis of the later science of spectroscopy. It was noted that the spectrum of a given element, say calcium, altered its appearance when excited in different ways. Certain lines were observed to be strong in one source, while in a second source another set was stronger, and much interest was given to this phenomenon by the fact that astronomers noted similar differences in celestial spectra. In one type of star certain lines of an element were strong, in another they were weak or absent. It was realized that when the cause of these differences was understood, the physical state of a star could be judged by its spectrum, when otherwise we knew nothing beyond its relative brightness and

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general color. To know what these differences might mean, we must find out how to produce in the laboratory the same sort of changes, and by controlling the conditions, discover the causes of the differences. And so a new department of spectroscopy developed, in which we took the known lines of an element and used them to indicate the state of the luminous vapor producing them.

That we may understand our methods better, I will mention several of our standard sources of light for spectrum study. Each of them has been used in a great variety of forms by different investigators. The first is an ordinary Bunsen flame which may be colored by various substances. We have the well-known yellow flame of sodium, the red of lithium, the green of copper, each of these colors being caused by certain strong lines in these regions of the spectrum. If a substance is vaporized in the electric arc, many more lines appear. When titanium is thus vaporized, the brilliancy of the arc and lack of any decided color are due to the fact that a large number of lines of different wavelengths from the red to the violet are being emitted. Now it was early observed that the lines strong in the flame are often not the most prominent lines in the arc. The arc shows many additional lines and for some elements the lines given by the flame are relatively weak in the arc. These flame lines are of much astrophysical interest. Some stars show only lines of this type, and in the early work at Mount Wilson it was shown that these lines are much strengthened in sunspots. The flame is of lower temperature than the arc, and if one examines the outer, cooler vapors of the arc it is found that these flame lines are given there. Can they be used as an indication of low temperature? Chemical processes are taking place at a lively rate both in the flame and in the outer vapors of the arc. If the flame lines are due to chemical action, they will not help us in interpreting the stellar conditions, where almost any chemical reactions may be taking place. Again, if the arc is modified in various ways, it is found that some groups of lines are brought out by certain conditions and other lines remain unaffected. Is it a higher temperature or some obscure feature of the electric discharge which might not be duplicated in another light source such as a star? If we pass to the electric spark there is still more difficulty in assigning the effects to temperature differences. For most elements, the spark gives a set of lines which the flame does not give at all and which are faint or absent in the arc. These are called "enhanced lines." While the spark does not heat its terminals as an arc does, the extremely concentrated, high-voltage discharge indicates a disturbance, which, if not temperature in the ordinary sense, would take a very high temperature to duplicate its action. Some types of stars which on other grounds are considered to have very high temperatures show spectra consisting almost entirely of these enhanced lines. But astronomy offered some evidence which seemed contradictory. Observations during eclipses of the sun showed that the enhanced lines are emitted far out in space, in a relatively cool region of the sun's atmosphere. To explain this, Sir Norman Lockyer advanced the bold hypothesis that the enhanced lines are due to a modified form of our chemical elements which he called proto-iron, proto-calcium, etc. I will touch later on the recent explanation which to a considerable degree reconciles the apparent contradictions.

The flame, arc and spark are used to vaporize substances which are in the solid or liquid state. Gases such as hydrogen, oxygen, nitrogen, helium and the rare gases of the atmosphere are used at low pressure in glass or quartz tubes and excited by a spark discharge. The characteristic color results from the pre-

dominance of strong lines in a certain region of the spectrum, and this color may sometimes be altered by changing the character of the discharge.

From what I have said, it will be clear that we needed to know what agency, if any, was the controlling cause of the observed changes in spectra, if we are to use these observations to judge of the physical state of the sun and stars. We needed a source of light capable of temperature variation over a wide range, which would be as free as possible from chemical action such as occurs in flames and from the electric conditions of the arc and spark, whose connection with temperature was not clear.

An electric furnace was devised to fill this requirement. The method was to vaporize substances in a carbon tube, beginning with a temperature just sufficient to show a few lines, such as appear in a low temperature flame, and proceeding by gradual steps as nearly as possible to the temperature of the electric arc. Experiments of this sort have been carried on in the Pasadena laboratory of the Mount Wilson Observatory for a number of years. We have here a replica, reduced in size but quite effective in operation, of the latest type of tube furnace in use in Pasadena. The substance whose spectrum we wish to study is placed in a tube of Acheson graphite, a very pure carbon. The tube is held in water-cooled clamps, and a heavy current heats it to any desired temperature up to about 3,000° C. A water-jacket, surrounding the tube a little distance from it, carries away the surplus heat. The whole is enclosed by a hood, and when this is clamped on, the apparatus is pumped out and operated in vacuum. The light passes to the spectroscope through one of the windows in the hood, while through the other window the temperature of the tube may be closely measured by an optical pyrometer.

Before discussing the work in which the larger furnace of this type has been most used, I will speak of a few of its special uses. While the spectra usually consist of bright lines, dark absorption lines may be obtained similar to the Fraunhofer lines of the solar spectrum, by passing a beam of white light, perhaps from a brilliant tungsten lamp, through the tube when the furnace is heated to a known temperature. If we wish to study the spectra of compounds, which occur in the cooler stars, a gas such as oxygen, hydrogen or nitrogen may be passed through the tube in which a metal is being vaporized, and the spectrum of the oxide, hydride or nitride observed. The change from the line spectrum of the metallic atom to the band spectrum of the compound molecule is then seen. High pressure of the gas inside the chamber results in a change of wave-length of the spectrum lines. This has been studied with a thick-walled furnace and the lines are displaced from their regular positions. The refraction of hot vapors, which has been advanced as the cause of some solar phenomena, is another field in which the furnace has been useful. These anomalous dispersion effects have been observed for a variety of elements.

We will now turn to the chief use of the furnace, the study of metallic spectra at known temperatures. The tube being charged with the metal or salt to be studied, a temperature is first used just high enough to vaporize the substance and produce a small number of lines. These low-temperature lines are of special interest as criteria of reduced temperature in celestial spectra and are fundamental in studies of atomic relations based on the spectral characteristics. Higher temperatures of the furnace bring out other groups of lines, until at the highest temperatures regularly used, from 2,500° to 3,000° C., nearly all lines appear which are present in the arc spectrum, but the relative in-

tensities are quite different. Some of the low-temperature lines undergo little change at higher temperatures and in the arc, indicating that the proportion of atoms which can emit these lines is not materially increased at higher temperatures. Other lines gain in intensity at higher temperatures and are very much strengthened in the arc. Still others appear first at medium temperature and strengthen rapidly, and others require the highest temperature. Some strong furnace lines are distinctly weakened in the arc. This is an interesting type of which a few lines appear in most spectra, and it is found in general that a certain range of excitation is most favorable for the production of lines of a given type. The range of temperature available with the furnace is such that the most favorable excitation for a given set of lines may be found. This is true even for metals of high melting points, such as titanium and vanadium. These elements, prominent in solar and stellar spectra, give no lines below 1,900° C., but with the range of temperature available in the furnace, the full variation of lines up to the arc can be brought out.

We are dealing chiefly, in these furnace and arc spectra, with the radiation of the neutral atom, that is, with an atom which has a central positive charge of a certain value, and around this positive nucleus a number of electrons whose total negative charges are equal to the positive charge of the nucleus. It is possible, however, under conditions of high excitation, both in our laboratory sources and in the stars, to displace one of these electrons beyond the attractive force of the positive nucleus, and we have what is called an ionized atom. Our atom is no longer in electrical equilibrium, and it gives out an entirely different spectrum consisting of the enhanced or spark lines which I have mentioned. Judged by its radiation, this ionized atom is a different element from that which we have before the electron was knocked off. Sir Norman Lockyer was right when he spoke of "proto-elements" as giving these enhanced lines in very hot stars and in the solar chromosphere, though it was only after his death that the manner of production of these lines became fairly clear. For a large number of our chemical elements we know the "ionization potential," the number of volts which gives energy enough to separate an electron from the atom which has bound it. There are large differences, ranging from 3.88 volts for caesium to 24.4 volts for helium. This energy is analogous to heat of vaporization, the energy which must be applied to a liquid to change it to a gas, and after supplying this atomic heat of vaporization we get an electron gas, a perfect gas, to which the laws of thermodynamics may be applied. Saha has shown that in the production of this electron gas reduced pressure plays a large part, as well as high temperature, which is the key to the fact that in the outer vapors of the sun as they extend into space the lines of the ionized atom are relatively strong. In the laboratory, a source under reduced pressure, such as an arc in a vacuum chamber, gives also the ionized spectrum.

Ionization need not end with separating one electron. A second, third and for chlorine up to the sixth may be knocked off, and we get in each case what is essentially a different element, emitting a new spectrum. Since the atomic number of an element indicates the number of electrons distributed about the nucleus, it follows that Na (11) should have the same number of electrons as singly ionized Mg (12), doubly ionized Al (13), and trebly ionized Si (14). This need not mean that they are the same elements, since the nucleus may be different, as well as the arrangement of the remaining electrons, but the arrangement of the spectrum lines has been found to be very similar

for the elements in these states, and the resemblance has been followed by means of this "displacement law" as far as Cl (17) which when it has lost six electrons has a spectrum resembling neutral Na (11). It follows from this that the loss of one electron in a spark discharge gives in general a spectrum resembling the arc spectrum of the element of one less atomic number. This relation has been verified for many elements.

Let us now consider what happens when spectral lines are emitted by a hot vapor, and what these lines tell us about the atoms of that vapor. Without taking up the very ingenious atomic models, which are necessarily hypothetical, we can base what is necessary for our present purpose on a few quite self-evident facts. A vapor is rendered luminous as a result of receiving energy from its surroundings, as when it is heated in the furnace tube or in the electric arc. The energy which it receives is given out as radiation of a certain wave-length. The atom has taken up energy and then given it out, and we speak of it as having passed from one stationary state to another, and since the atom has different amounts of energy in the two conditions, we speak of these states as energy levels.

From the first it has been quite evident that some lines require much less energy to excite them than others. These are the low temperature lines, and in connection with recent atomic theory, we designate them as of low energy level. Lines requiring higher temperature belong to higher energy levels. It is thus evident that the distinct grouping given by successive temperatures of the furnace indicates the relative energy levels to which these lines belong.

During the past few years, great advances have been made in the study of regularities in spectra. Lines in the same region of the spectrum and groups of similar type in different regions are found to be connected by very definite numerical relations and form what is known as spectral series. These arrangements of lines are connected with the properties of the elements in a way as yet imperfectly understood. For a number of years the classification of lines by means of the furnace has been of much assistance in sorting out groups of similar type for arrangement in series. Up to a very few years ago, spectra such as iron, chromium or titanium gave the troubles of an embarrassment of riches; but groups were found, having sometimes up to fifteen lines, which appeared at a certain temperature of the furnace and were exactly similar, in arrangement of their lines, to other groups appearing at the same temperature in other parts of the spectrum. The multitude of lines appearing in the arc were thus divided into small groups which obviously arose from the same conditions of the atom, furnishing an additional method very useful in making the spectrum indicate atomic states.

If we compare the arc and spark spectra of iron, we find that the spark consists largely of the lines of the ionized atom, as in the spectra of the hotter stars, while the arc lines of the neutral atom have for the most part disappeared. However, enough ionization exists in the arc to emit the stronger enhanced lines; also some neutral atoms persist in the spark and show the stronger arc lines. By varying the spark conditions, the enhanced lines can be weakened and the spectrum gradually changed into that of the arc. Elements differ greatly in the energy required to ionize their atoms, and some, such as calcium, strontium and barium, show the spectrum of the ionized atom at very moderate temperature of the furnace. The spectrum of vanadium for three temperatures of the furnace, also of the arc and the spark, may be used to illustrate the changes with increasing excitation. A great number of lines are given in the spectrum of

the arc. It was regarded as hopeless to sort this mass of lines into groups arising from different states of the atom, but the furnace does this quite effectively. At 2,000° we have several of the multiplet groups whose lines are connected by definite numerical relations. At 2,300° and 2,600° the spectrum becomes steadily richer by the addition of groups of lines from other atomic conditions which require more energy to give radiation. In the spectrum of the spark, the principal furnace lines have largely disappeared. The stronger lines are those of the ionized atom, but some of these are present also in the furnace as low as 2,300°, increasing rapidly in strength through the arc into the spark. We thus see that the change is a continuous one, as the excitation increases, from the low-temperature furnace corresponding to the flame spectrum, up to the spark, corresponding to the spectra of the hotter stars, where the temperature is so high that the atoms are largely ionized. The various types of stellar spectra illustrate this gradation. The hotter stars show the lines of hydrogen and the spark lines of the metals, those of type similar to the sun show the arc and high-temperature furnace lines, the predominance of low-temperature lines and the band spectra of compounds distinguish the cooler stars. If we compare the spectrum of a sunspot with that of the solar disk, we find that the lines strengthened in the spot are invariably those given at low temperature in the furnace. Those weakened are usually those of the ionized atom. These phenomena, together with the presence of bands due to molecules, have established the low temperature of sunspots.

There are many high-temperature lines, given rather faintly by the arc and by the high-temperature furnace, which belong to the neutral atom and for which we need a greater concentration of electric energy to show their variations and group them as we have the other lines. This may be obtained by arcs using very powerful currents, in which I have recently examined the spectra of a number of elements. A current of 1,000 amperes or more is used in an arc between small rods of the metal. The arc is a blinding flash, lasting a fraction of a second before the terminals burn so far apart that the arc breaks. Pictures made with a rotating mirror camera show the arc to be a thin spiral between the terminals. The high concentration of energy when this constricted spiral of iron vapor carries 1,000 amperes indicates a great difference from the quietly burning arc, carrying some 5 amperes. The spectrum shows the results of this concentrated energy. The lines strengthened in the high-current arc are high-temperature lines which neither the furnace nor the ordinary arc gives strongly enough to show their characteristics. In the high-current arc they strengthen to different degrees, widen some toward the violet, others to the red, so that it is possible to group these difficult lines according to their structure and degree of strengthening. Low-temperature lines are not strong in this arc. The lines greatly strengthened are faint and difficult in our ordinary sources. A very interesting feature is that lines are often shifted in position, their wave-length being changed from that of the ordinary arc. Further investigation will probably show this is due to the electric forces of neighboring atoms, closely packed and under high excitation. Another source of great electrical energy, in which currents in the thousands of amperes act for a few millionths of a second, are the wire explosions, which have been studied by Dr. Anderson. In these experiments a large condenser, of about 10 microfarads, discharges through a thin metal wire. The temperature of the vapor in these explosions, estimated by two or three different methods, is of the order of 20,000° C., not so high as probably exists in very powerful spark discharges, but having

the advantage that a temperature in this high range can be measured and the corresponding spectrum observed. As related to other sources, the relative intensities of the spectrum lines are similar to those of the high-current arc, as would be expected from the great concentration of energy, but the extension into the ultra-violet and the stronger ionization indicates a closer approach to the conditions of the condensed spark.

In the laboratory light sources which I have described, the spectrum of the neutral atom may be studied through increasing furnace temperatures and reaches its full development in the high-current arc and exploded wires. That of the ionized atom usually appears to some extent in the furnace, develops along with the neutral atom radiation in furnace and arc until in the condensed spark the ionized atom gives practically the whole spectrum. A still higher stage appears when a spark is made to pass in a very high vacuum. Other electrons may then be torn off, and multiple ionization takes place.

I will indicate, for the sources in which the neutral and singly ionized atoms are active, how we may arrive at approximate temperatures for each of these stages. The temperatures of the furnace, up to about 3,000° C., may be closely measured with a pyrometer. Extrapolation is now needed for the temperature of the ordinary arc, and the other sources are a long step beyond. However, we have seen that the temperature of the wire explosions is approximately known. These explosions may be modified, by adjustment of circuit conditions, to approach more closely the spectrum of the arc on the one side and the spark on the other and the corresponding temperatures may be measured. We shall then know to a fair approximation the temperature indicated by a given type of spectrum, and the type of stellar spectrum will then tell more closely than at present the temperature of a star.

I have tried to give some of the problems and show some of the progress by the use of high temperatures in making the spectrum more fully an indicator of atomic conditions. While the work is only fairly started, it is a gratification to note that when physicists or astronomers come together there are many points which a few years ago invariably provoked an argument that are now considered as settled and accepted as a matter of course.

RADIO TALKS ON SCIENCE[1]

ECLIPSING STARS

By Professor JOEL STEBBINS

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THE astronomer is often asked what evidence there is of dark stars or planets revolving about the bright stars that we see in the sky. Perhaps the best proof of the existence of such attendant bodies is given by the spectroscope in the application of the so-called Doppler principle. Any one who has sat in a stationary train while locomotives were switching to and fro in the neighborhood will perhaps remember the sudden change in the pitch of an engine bell as it passes by on an adjoining track. While approaching, the bell has a certain pitch, but after passing the observer the bell suffers a distinct lowering of pitch as it recedes. This phenomenon is readily explained by taking into account the velocity of sound. With an approaching locomotive the observer gets more vibrations per second due to the velocity of the engine being added to that of the sound, while when the engine is receding fewer vibrations are received and the pitch is lowered. This same principle applied to light vibrations gives the possibility of determining the speed of the stars to or from the earth by measuring the exact color or wave-length, as it is called, of the lines in the spectrum of the star. Violet light corresponds to high pitch, red light to low pitch. It is thus figuratively true that each star has a pitch indicator which when compared with a standard light in the observatory will give at once the speed of the celestial object to or from us in miles per second.

1 Broadcast from Station WCAP, Washington, D. C., under the auspices of the National Research Council and Science Service and the direction of W. E. Tisdale.

Many of the large telescopes of the world are used in the application of the Doppler principle to the measurement of the speed of stars, and one of the outcomes of this work has been the discovery of so-called spectroscopic binary stars. It is found that a large proportion, as many as one fourth or one third of certain classes of stars, undergo periodic changes in velocity in the course of only a few days. At one time a star may be leaving us at fifty or even one hundred miles a second, while within two or three days the same object is found to be approaching at a similar rate, the simple explanation being that the star is in motion about the center of gravity of itself and some large companion. Also there have been found objects in the sky where at times the lines of the spectrum are doubled, showing that the star is at the same time both receding from us and approaching toward us, a phenomenon which can be due only to the motion of two separate bodies about the common center of mass. The first discovered twin object of this character was the bright star Mizar in the middle of the handle of the Big Dipper, whose duplicity, with a period of twenty days, was detected at the Harvard Observatory over thirty years ago. Of well-known bright stars, Capella in the northern sky is composed of two slightly unequal components with a period of revolution of about one hundred days. There are many other stars visible to the naked eye which have large companions with short periods.

In general it has been found that white stars are likely to have short periods, even as short as about one day;

yellow stars have periods not quite so short, perhaps down to ten days, while the red stars as a class are generally single bodies. The components of these short-period systems are far too close together to be detected by direct vision through the telescope, and it is only when the period is as long as several years and the system is relatively near to us that the companion body may be seen. It is the advantage of the spectroscopic method that the closer two stars are together the more rapidly do they move, and hence the more readily are they detected.

With many double stars of this sort in the sky, we should expect a certain number to have orbits at just the angles required for one body to pass in front of the other and cause an eclipse similar to that of the sun by the moon. Observation shows that there are many such eclipsing systems. The best example is the well-known star Algol, which normally is about as bright as the Pole Star, but at intervals of sixty-nine hours—three hours less than three days—it loses about two thirds of its light during the course of five hours, and then in five hours more comes back to normal. This eclipse repeats itself regularly, and has been observed for over a century, so that we now know the period of revolution of the satellite to within perhaps a second of time. It may also be noted that when the fainter component goes behind the bright star there is a second eclipse amounting to about 6 per cent. of the total light, showing that the so-called companion is not dark but about one tenth as bright as the main star.

Inasmuch as Mercury, the nearest planet to the sun, requires eighty-eight days for its revolution, it was a long time before astronomers could be convinced of a dark star large enough to cut off two thirds of the light of the primary, and which would be so close as to revolve in three days. However, other shorter periods, even down to one day, have been found, and the spectroscopic determinations of the motions agree completely with the eclipse theory.

One of the recent advances in stellar photometry has been the measurement of these small changes of light of eclipsing stars. As the eye is ordinarily insensitive to changes of say 5 or 10 per cent., some improvement upon visual observation is necessary. This has been made possible by the photoelectric cell, which is a device for transforming light received into an electric current. Physicists have known for a long time that a fresh and clean metallic surface will liberate electrons under the influence of light, and the photoelectric cell is a means for intensifying this effect. An alkali metal, such as sodium or potassium, is deposited on one side of a glass bulb much like an ordinary incandescent lamp. This is filled with an inert gas such as helium or argon, and when connected in a proper electrical circuit a measurable current is produced by exposure of the cell to light.

It is interesting to note how far pure science has been ahead of applied science when we consider that these photoelectric cells have been used for experiments in the physics laboratory for over thirty years and that for a dozen years they have been applied to measurements of the light of stars, but it is only within the last two or three years that they have been used in what might be called practical applications, such as long distance transmission of photographs over wires or by radio.

For measuring the light of stars. a photoelectric cell is placed in a box with a small diaphragm at the focus of a telescope so that the light from only one star at a time can affect the cell. The cell is connected with a delicate electrometer, and the observer, after having set the telescope on the proper star, observes in a microscope the motion of a fine wire across the field of view. The brighter the star, the greater is the elec-

trical current, and hence the more rapid the motion of the wire of the electrometer. The observer notes by means of an ordinary stopwatch the time required for the wire to move between two divisions of a scale and thus measures the light of the stars in much the same way as he would record the start and finish of a foot race.

Because of variations in the clearness of the earth's atmosphere, it is necessary to compare one star with one or more others close by in the sky. Sometimes it happens that the suspected variable star turns out to be constant in light while the standard star does the varying. Our sun itself is known to be an irregularly variable star, changing in the amount of light and heat sent to the earth by several per cent., sometimes as much as 5 per cent. within a few days or a week, but on the whole most of the objects in the sky are found to be reasonably constant, that is, within 1 or 2 per cent. for long periods of time.

In searching for eclipsing stars among the known spectroscopic doubles, it is found that eclipses to the amount of 50 per cent. or more are unusual, but there are frequent partial eclipses of 10 per cent. or less. The whitest stars, the so-called helium or blue-white stars, like those in the constellation of Orion, are most likely to have large companions which will produce eclipses. In fact, if we take those which are known in advance to be favorable in this class of stars, it is found that more than half actually do show eclipses. Of stars not quite so hot, those of the color of Sirius, about one third have shown eclipses. This means that in the second class the companion stars are relatively smaller and farther away from the primaries. Of the cooler yellow stars, like the sun and the red stars, very few indeed have periods as short as ten days or two weeks, and of these practically none have been found to show eclipses. The conclusion from this is that the components of white double stars are large as compared with the distance between them, sometimes the objects being almost in contact, whereas in the yellow and red stars the companions are farther away, smaller and more condensed.

Any one familiar with the appearance of the sky at all knows the seven stars of Ursa Major, or the Big Dipper, as it is called. It would seem a peculiar coincidence if as many stars as this of about the same brightness should happen to be in the same direction from us, and it turns out that five of the stars have motions parallel with each other in space. The star in the bowl of the Dipper, nearest the pole, and the one in the end of the handle do not share in this motion, but the others are moving together in parallel lines, although the distance between any two of them is as great as the distance between the sun and some of our nearer neighbors. What is more striking about this Ursa Major group, however, is that distributed around the sky are some twenty other objects, all of which are moving parallel to the bright stars in the Dipper. One of the members of this extended group is Sirius, the brightest star in our sky. The ancients drew a large bear in the northern and a large dog in the southern sky. Now that Sirius belongs to the Bear we may say that the Great Dog has part of the Bear's tail in his mouth.

Two of the members of the Ursa Major group have been found to be eclipsing variable stars, and a detailed study of these gives us probably an indication of the characteristics of the other stars. The first one is Beta Aurigae, a second magnitude star near Capella. This is shown by the spectroscope to be a twin system with each component moving about one hundred miles per second around the center of mass in a period of four days. During six hours of the revolution, one body is in front of the other, producing an eclipse of some 7 per cent. Since we know how fast the

stars are going, we have the distance one body must move to pass in front of the other component; thus the combination of the spectroscopic and photometric measures gives the diameter in miles of each star and their distance apart. It is found that each component is two and one half times as heavy as the sun, and about two and one half times the diameter, giving a density of about one seventh on the solar standard. From the apparent brightness and measured distance of this system, we also have found that each component gives one hundred times as much light as the sun, or two hundred times for both. Truly this is a giant system.

The other eclipsing star, Alpha Coronae, the brightest star in the Northern Crown, has a companion with a period of seventeen days, but the time of eclipse is only twelve hours. In the same manner as for Beta Aurigae, it is found that the main star has three times the mass and over twice the diameter of the sun. The companion, however, is practically a dark body, somewhat smaller than the sun, and is found to be nearly four times as dense as the sun or about equal in density to the earth. Until recently this would have been called a very dense heavenly body, as when we stand on *terra firma* it turns out that we have chosen one of the heaviest bodies for its size known anywhere in the universe. However, recent developments have shown the existence of far heavier stars, which exist as attendant bodies, and one of these is the companion of Sirius.

In a series of brilliant theoretical investigations, the English astronomer Eddington has shown that the central regions of stars, whether they be apparently white and hot on the surface or red and relatively cool, are probably at a temperature in the interior well up into the millions of degrees. He has also shown that at these extraordinary temperatures we may expect the material to act as a perfect gas long after it would be compressed into a liquid or solid under ordinary conditions. The center of gravity of Sirius and its companion can be located, and it is found that the bright star is two and one half times as heavy as the sun, while the companion has about four fifths of the solar mass. On the other hand, this companion gives only one ten-thousandth as much light as the bright star, but nevertheless its surface is white hot, much more brilliant than the sun. There seems no escape from the conclusion, then, that this is a very small body and it has a diameter about one thirty-fifth that of the sun, or about the size of Uranus. Further observations with the great telescope at Mt. Wilson have verified Eddington's theory, and it turns out that the material of this companion must average about fifty thousand times the density of water. Such a weight per unit of volume is far beyond anything in direct human experience. A pint of the material would weigh twenty-five tons. A man could not even support as much as a ring of it around his finger. Things are far more exaggerated when we consider the conditions on the surface of such a star. On the earth, if one throws a ball out of the window it will fall sixteen feet the first second. On the companion of Sirius, such a hypothetical projectile would drop towards the center of the body no less than one hundred miles in the first second. In fact, we must revise all our notions of the properties of matter when we consider what may happen at a temperature of some millions of degrees.

Since all the stars of the Ursa Major group are much alike in color, it is probable that Sirius and the two eclipsing stars we have mentioned are fair samples of the general system. At any rate, whenever we look up at the Big Dipper, we can say with Shakespeare:

> At first I did adore a twinkling star,
> But now I worship a celestial sun.

SYNTHETIC RUBBER

By H. E. HOWE

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For almost twenty years the question of synthetic rubber has periodically come to the surface, only to be again submerged by circumstances, the chief factor in which has been cheap natural rubber. In 1912 at the International Congress of Applied Chemistry in New York the official representative of the German Empire displayed among other articles used to emphasize German contributions to industry a set of automobile tires composed of synthetic rubber. These tires were said to have run some four thousand miles, but there was no way of checking this statement and some doubt has since been expressed as to whether they were composed wholly of synthetic rubber. The lecturer admitted that the difficulties to be overcome before the process could be commercial were very numerous, but promised that science would not give up until victory had been won.

Since 1912 crude rubber from the plantations has occasionally sold at very low prices, has occasionally attained very high prices, but until recently has been maintained at such a price level as to make the development of synthetic rubber unattractive.

It is not surprising to find a wide interest in the possibility of synthetic rubber. It has already been demonstrated in the case of many complex substances such as indigo, glandular principles for medicinal use, one of the popular flavoring extracts, and the fixation of atmospheric nitrogen—to mention but a few examples—that science through the research laboratory can produce materials that really duplicate those of nature, or if not complete duplicates, then articles which supplement the supply of nature or which can be used in their stead. What is there about rubber which should make it less possible to produce it in the laboratory than to make some of these other articles that are of everyday commercial acquaintance?

To begin with, it must be realized that rubber is a complex substance. It has a number of unique characteristics. It is very plastic before it is vulcanized, and after vulcanization it has remarkable elastic properties and high resistance to abrasion. It is not the rubber hydrocarbons themselves that present the greatest difficulty, but the nature of the rubber particles. The latex which comes from the rubber tree is a liquid, perhaps a colloidal solution of a mixture of three or four hydrocarbons with non-rubber substances, principally proteins. In the process of coagulating the latex the precipitated rubber particles are probably surrounded by a thin film of the proteins or other non-rubber substances. This arrangement seems to be the same in all particles, and the exact duplication of such a system is unquestionably very difficult. We repeat "difficult" and avoid using the word "impossible," because many things have been done in the research laboratory which were freely characterized, even by the devotees of science, as impossible.

During the war a material called synthetic rubber was produced in Germany from acetone, but nothing is known of the yield or the cost. The quantity is believed to have been about forty tons per month, but this material was satisfactory only for hard rubber articles. When you consider the proportion of manufactured rubber goods that are sold in the form of hard rubber, you will realize that a material suitable only for such articles can not be considered a real substitute for crude rubber. Not only was this material lacking in elasticity but was also very short-lived.

It has been known for many years that when crude rubber is subjected to destructive distillation a compound called isoprene is obtained and that this same material results when turpentine is given the same treatment. It was but natural then to give turpentine serious consideration as the starting point in the production of isoprene from which crude rubber could be made. Work along this line has not been successful because of low yields. Furthermore, it has become more and more evident that the use of turpentine is unsound economically, for if the synthesis were successful the supplies of raw material would be wholly inadequate. Attention was turned to other materials, including the family of olefins and diolefins obtained from petroleum and chemical compounds that could be derived from coal tar and from starch. The early workers discarded petroleum as a source of raw material, while coal tar was favored in Germany, and starch in England. More lately petroleum has received the attention of American chemists.

Without going into technical detail it may be said that much research is in progress along these three lines. There is no doubt about the difficulty of the work in hand, for after the parent hydrocarbon has been selected and produced on a commercial scale, the scientist is still confronted with the further and distinct operation of causing that hydrocarbon to polymerize, that is, build up a large complex molecule from many smaller and more simple ones. Isoprene and methyl isoprene will polymerize upon standing at atmospheric temperature, but the reaction takes place very slowly and the yields are low. If the temperature is maintained at 60° C. polymerization takes place in from four to six months. Various materials have been tried to assist or to hasten this action.

While synthetic rubber is not an item of commerce to-day and probably is produced nowhere except on an experimental basis, it has been brought to the fore by return of high prices and by the prospect of a distinct rubber shortage within the next few years, due to inadequate planting of new rubber trees in the Far East and to steadily increasing demand for crude rubber, coupled with certain restrictive legislation put into effect by Great Britain. The failure to plant trees as rapidly as world demands would make advisable and the enactment of the restrictions upon crude rubber exports came about from low prices which crude rubber brought a short time ago. So large a proportion of the crude rubber is produced under British control that it became a simple matter to regulate export so as to adjust supply and demand in a fashion to increase prices. Little fault is found with those producers of British rubber who had the foresight and courage to proceed to develop plantations, while others showed no interest in such enterprises, but a great deal of criticism has been leveled at the British government for officially taking a hand in the creation of a monopoly in crude raw materials. Many believe that the shortages which are imminent and the prospect of several years of high prices can not fail to stimulate new interest in the production of crude rubber from hydrocarbons derived from starch, from coal tar or from hydrocarbons produced as by-products of the petroleum industry.

The technical difficulties have been mentioned. A further consideration is the economic phase of the question. The Department of Commerce in its crude rubber investigations reached the conclusion that the plantation rubber industry can live and prosper on present yields of rubber per tree when rubber sells for thirty cents. The manufacturer of synthetic rubber therefore must not only be able to achieve uniform production and produce material with most of the characteristics of rubber, but he must do so

at not more than thirty cents a pound. It must be borne in mind also that while the research laboratory is busy on the problem, the rubber tree offers the agriculturist a great opportunity. There may be ways of bringing the tree into production in a shorter time after it is set out than is at present the case. It seems almost certain that trees can be developed which will resist disease to a greater extent and perhaps yield more rubber per tree. Surely, if the agriculturist can accomplish in this field what he has done in the case of the sugar beet, wheat, corn, the nut-bearing trees and in many other directions, the chemist has a very large handicap with which to contend.

On the other hand, we know that rubber is now used in many places for which it is not the ideal material and where the service to be performed does not call for all the peculiar characteristics of rubber. A synthetic product may be developed which will serve in an entirely satisfactory way this large and diverse demand, leaving to crude rubber an ever-growing field where utilization appears to be limited only by price.

In view of the difficulties, the prospects, and all the conditions, is it worth while to continue the search for synthetic rubber? Unquestionably it is. The extent to which rubber has entered into our everyday life is in itself a sufficient reason for conducting research looking to the synthesis of so essential a material, and this is particularly true in America, where we consume more than 70 per cent. of the world's production of crude rubber and produce none. Even though synthetic rubber may not be produced in the near future at a price to compete with crude rubber, there are times when price is a minor consideration and there is also the prospect of further discoveries that will lower costs and improve the product. The ability to produce synthetic rubber of satisfactory qualifications on demand would constitute a great defense against higher and higher prices and give a degree of independence that would be worth more than the cost of the research.

The prospect of synthetic rubber satisfactory in quality and commercial in price grows brighter day by day because of the gradual increase in our knowledge. As the scientists develop new facts regarding crude rubber, more will be learned on the production of synthetic rubber. As our knowledge of the use of high temperatures and high pressures increases, as we gain more information concerning catalysts, and how they perform their functions, and as the organic chemists establish a longer and ever longer list of relationships between atoms and molecules, and as the physical chemist becomes better acquainted with the structure of the molecule and the atom, we may expect wholly new developments in the field of synthesis and unexpected things will be accomplished in the synthesis of rubber.

HOW OLD IS THE EARTH?

By Dr. JOHN H. BRADLEY

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EMERSON once said that "everything in nature is engaged in writing its own history." As long ago as one hundred and fifty years, a handful of men in several European countries, before Emerson had made his declaration, came to the conclusion that the earth had written its own history. These men set out to unravel the tangled skein of the earth's story and in so doing founded the science of geology. Geologists are the historians of the earth, and it is as a geologist that I wish to write. As a geologist, however, I am not going to tell you how old the earth is, because I do not know. I am not going to say what the consensus of expert opinion concerning the age of the earth is, because there is no consensus of expert opinion. I am merely going to attempt to show why the student of earth history is best fitted to tackle the problem of the age of the earth, as well as how he has attacked it and something of the general results he has obtained.

Opinions concerning the age of the earth may be divided into two great groups, the one derived from a consideration of the account in Genesis or other documentary evidence, and the other derived from a conscientious attempt to make the earth give up its own story. I shall not speak about any of the documentary accounts, other than to say that any belief, no matter how gained, which ascribes but a paltry five or six thousand years as the age of the earth, is emphatically denied by the only person who has any right to pose as an authority on this subject. That person is old Mother Earth herself, perhaps the only member of her sex who persistently and insistently proclaims to those who can understand her that she is very old. She is so old, indeed, that to attempt to measure her age in years is as absurd as to attempt to measure the volume of water in the Pacific Ocean with a teacup. She is so old that man, whose own life is so short, has the greatest difficulty in imagining the vast ages which have elapsed since her birth. We can only with difficulty conceive of the time which has passed since the giant sequoia trees of California were seedlings, and yet the few thousand years through which these oldest of living things have endured are but a moment in geological time and have added scarcely a wrinkle to the already deeply furrowed face of earth. The discovery of the tomb of Tut-Ankh-Amen has recently fired the public mind with the glories of antiquity, and yet when viewed in the perspective of the past history of the earth or even that of man, who has probably existed for at least fifty thousand years, King Tut becomes a modern monarch, and the few thousand years which separate him from us fade into insignificance.

Despite the calm and apparently immovable expression on the earth's face, changes of great importance have taken place in that expression since the beginning of the earth's existence as a separate entity in the solar system. If you and I could return to our favorite haunts in the mountains or on the seashore after a sojourn of five thousand years elsewhere, we should probably detect very little change. To be sure, our favorite trout lake might have been filled with sediment and converted into a cow pasture, or drained by a river, during our absence, because lakes are

peculiarly evanescent phenomena and short-lived without exception. We might find that the stream which once flowed into the ocean a half mile from our seaside bungalow now flowed into the ocean over the very site of the bungalow. We might even find, if the bungalow had been situated on a low, wide beach, that its site now functioned as a portion of the sea bottom, half a mile from shore. Nevertheless, we should detect very little change in the larger features of the landscape. The mountains, although they had been attacked by rain, frost, snow and other agencies which gnaw at and tend in time to destroy rocky eminences, would not appear noticeably lower. The general configuration of the coast would very likely be but little changed.

If, instead of five thousand, we should return after a million years, we might be startled by the changes we should see. Our mountains might be worn down to pitiful stumps or even to a flat plain with nothing to indicate their former grandeur. The sea might have advanced upon the land so that vast regions now dry would be covered by marine waters teeming with creatures quite different from those which inhabit the seas to-day. The life of the lands might have a strangely exotic appearance and even our own descendants might appear so vastly different from ourselves that we could not recognize them! Such changes have occurred again and again in the past; why should we not expect them to do so in the future?

For many years poets have sung of the "everlasting hills," of the permanency of their physical environment. With the progress of geological science, it has become clear that nothing is more certain than that the hills are not everlasting, that some day the highest mountain peak will crumble and fall away, perhaps to rise again at a later date. Whole mountain ranges are known to have been built and removed within but a small fraction of geological time. As it is with the mountains, so it is with many other features of the face of the earth. Nothing endures; the earth as we know it to-day was very different yesterday and will be very different to-morrow.

This conception of perpetual change in nature took form at an early date in the human mind. The first ideas of a world in constant flux were not based upon carefully observed fact and were not destined to take a firm and lasting hold upon the minds of men. The natural instincts of man work to obliterate the belief in the impermanency of things, because of fear of the unknown and the uncertainty which change brings. It was thus that the doctrine of evolution in plants and animals, although conceived at an early date, languished until the middle of the last century when it fell like a thunderbolt from the pen of Charles Darwin upon the reason of thinking men. Now it is known that the ebb and flow, demonstrated so clearly for the races of plants and animals, is true of their physical environment as well.

One poet of the nineteenth century saw life and the world through the truth-seeking eye of science, and I take the liberty of quoting a few of his stanzas. The poet was Tennyson, and the lines are from "In Memoriam:"

There rolls the deep where grew the tree.
O earth what changes hast thou seen!
There where the long street roars, hath been
The stillness of the central sea.

The hills are shadows, and they flow
From form to form and nothing stands;
They melt like mists, the solid lands,
Like clouds they shape themselves and go.

Last summer I stood upon a high peak in the Montana Rockies and dug from the rocks upon its crest a large quantity of fossil sea shells. The rocks themselves were clearly the consolidated sediments of an ancient sea floor, which at

one time occupied a great trough out of which the Rocky Mountains at a much later date raised their lofty heads. We might well join with Tennyson in singing "O earth what changes hast thou seen." The elevation of the Rocky Mountain district is only one of the many changes which have taken place during geological history. It is the business of the science of geology to detect these changes and to estimate the time nature has taken to effect them. Let us see how these estimates are made.

I have said that I can not state the exact age of the earth. One of the reasons for this is that the early stages of the earth's history are shrouded in mystery. There is good reason to believe that the earth had a bi-parental origin just as you and I. The earth is the child of the sun, its mother, and of a visiting star, its father, which, approaching close to the mother sun, forcibly extracted the earth, as well as its sisters and brothers, the other planets, by the tidal pull which all celestial bodies exert upon each other when they approach within a certain radius. After a long evolution, how long nobody knows, the earth grew by gathering in the star dust which it encountered in its path around the sun, gradually attracted an atmosphere, and rapidly cooling, finally acquired standing water in the depressions on its surface. Not until the acquisition of an atmosphere and an ocean did the earth begin to record its age.

It has long been known that the oceans were among the earliest permanent features to develop on the earth's surface. It is also known that in the beginning the oceans were fresh and that the salt which we now find in all sea water was largely brought from the land by rivers. For a long time geologists have been interested in estimating the age of the ocean on the basis of the rate at which salt is supplied to the sea by rivers. As early as 1715, Edmund Halley suggested the possibility of ascertaining the age of the oceans in this way. Not until 1899 had sufficient data accumulated to make such an estimate possible. In that year, Joly, the British physicist, using the figures at hand for the yearly amount of salt in river water and the estimated amount of salt in the sea, by simply dividing the second by the first, calculated that the oceans were ninety-seven million, six hundred thousand years old. Other estimates have been made, but all give nearly one hundred million years as the age of the sea. Any estimate of this type must forever be of a very general nature, because no one can ever know the rate by which rivers of the past have added salt to the sea. Since the estimates just cited are based on the present yearly amount of salt carried into the sea and since there is good reason to believe that this rate is much higher now than during most of the past, the oceans would appear to be at least one hundred million years old and probably much older.

In addition to salt, rivers carry great quantities of rock material worn from the land and finally deposited in the sea. The Nile dumps over fifty million tons of rock débris upon its delta every year. Yet the removal of this tremendous tonnage of waste from the land does not affect the general appearance of the land unless continued for a very long time. We may dwell throughout our lives on the bank of a river, and yet see no apparent widening of the valley. Rivers, however, do widen their valleys, but at a tremendously low rate compared with the brief span of a human lifetime. At St. Louis the bluffs of the Mississippi River stand about twenty miles apart. At one time the Mississippi was a young river and its valley walls were close together. At some future time, if conditions remain the same as they are to-day, the bluffs flanking the Mississippi will be appreciably farther apart. With time

rivers not only widen their valleys, but reduce great tracts of land to essential flatness. At the present rate of river wear, the widening of the Mississippi valley at St. Louis must have taken at least one million years. The reduction of the entire area drained by the Mississippi to flatness would require much longer, perhaps tens of millions of years. Now, there is good evidence in the rocks that rivers of the past have repeatedly worn great areas nearly to flatness, so that the age of the earth based upon the present rate of river erosion would be near one hundred million years.

In the course of earth history great deposits of rock waste have been heaped up in shallow marine basins which have again and again formed upon the surface of what is now the dry land of the continents. These deposits in time were consolidated, uplifted and preserved as rock. More than sixty-five miles of these so-called sedimentary rocks have been formed in the course of earth evolution. It has been estimated that at least one hundred million years were consumed in the accumulation of this vast pile of rock waste.

When the geologist turns his eye to the mountains, he finds abundant evidence to prove that mountains are built very slowly. Most convincing, perhaps, are certain rivers, which hold their courses athwart a region of uplift, and cut into the mountains as fast as they rise. Such a stream was the Columbia. This river was unfortunate enough to be flowing over a region destined to be elevated into the Cascade mountains. As the mountains rose the river cut down into them and suffered little or no deviation from its original course. To-day it can be seen flowing placidly through the heart of the Cascades, over the course it had followed before the mountains existed. We know that rivers cut into their channels very slowly, so we infer that mountains cut by such persistent streams as the Columbia must have risen equally slowly. Yet in the history of the earth lofty mountains have been repeatedly lifted and worn to flatness, leaving nothing but their stumps and great piles of rock débris to commemorate their former eminence. While the time involved can not be determined in years, it must have been great; so great that the human imagination can not fully grasp its significance.

Most people know that many of the plants and animals of the past are preserved as fossils in the rocks of the earth. These fossils give us a picture of the changing appearance of living things during the long eras of geological time. How fast did these changes take place? We know that the plants and animals of to-day are not noticeably different from those described in the earliest human documents. Five, ten or fifteen thousand years may pass without effecting any appreciable change in the general aspect of the world's life. Yet changes of a striking order have taken place. Before man, the gigantic dinosaur ruled the earth, and before the dinosaur various races of fishes and lowly marine creatures vied with each other for world dominion. Whole dynasties of creatures rose to dominate the seas and lands of the past, only to fall into the oblivion of extinction, and to be succeeded by other dynasties. The very oldest fossil plants and animals show that a long ancestry, entirely unrevealed, must have gone before. All these facts prove that the earth is very old, so old that the brief flash of a year or a century loses all meaning.

In conclusion let me cite very briefly certain experiments which indicate even an older earth than any of the evidence mentioned thus far. A few elements in nature are known to be unstable and constantly breaking down into different

things. For example, uranium passes into radium, and ultimately, after many successive stages, gives rise to helium (a gas) and lead, which are stable products. The rate of this transformation can not be altered and is accurately known by experiment.

The age of a given rock or mineral can be estimated by measuring the amounts of uranium and helium contained. Since the length of time required to generate the helium, one of the end products of the decay of uranium, is known, sufficient data can be had to estimate the age of the specimen in hand. Thus a piece of rock from Ceylon was found to be two hundred and eighty million years old; other rocks were found to be five hundred million years old; while still other rocks were estimated to be as much as ten billion years old. Other methods of studying radioactive minerals and rocks lead to various results, but in general the estimates of the age of the earth based upon the so-called "radioactive clock" are from ten to fifty times higher than those based upon strictly geological evidence. This discrepancy is partly due to the fact that the geological methods can not measure the breaks or missing intervals so prevalent in the earth's history, and undoubtedly give rise to underestimation. Making generous deduction for the probable overestimation of the new and as yet unperfected radioactive clock, we may conclude, and still consider our conclusion a conservative one, that the earth is at least from three to five billion years old.

THE TRASH-CARRYING HABIT OF CERTAIN LACE WING LARVAE

By Professor ROGER C. SMITH

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AMONG the striking habits of insects, the trash-carrying habit of the larvae of certain species of Chrysopidae deserve especial mention. The little load of débris carried by these larvae suggests to the observer the shield of tribal warriors or a type of modern camouflage as carried out in the late war and by certain hunters of game.

The Chrysopids contain some species which are plentiful. The adults are known as "golden eyes" or "green lace wings." The larvae are often referred to as "aphis lions" because of their general use of plant lice or aphids for food. The species in which the larvae pile trash on their backs are all scarce or rare. They occur perhaps most commonly in the citrus groves. Other species have been taken on trees, shrubs and underbrush in New York, Virginia and Kansas, but they are not commonly seen even by collectors.

The Chrysopids as a family group possess some habits and devices for protection and defense which compare favorably with the most unique among insects. Among those best known, the following may be listed: The stalked eggs, the long, sharp jaws of the larvae, the long setae on the back of the larvae, the cocoon containing the pupa, the repellant glands of the adult and the protective coloration of all stages are all characteristics and properties which make for the preservation of the individual. There is another device which is predominantly protective and perhaps less well known, *viz.*, the trash-carrying habit of the larvae of certain species. It is indeed the most unique performance of these interesting creatures.

The true trash-carrying larvae are those carrying the inverted saucer-shaped packets of débris upon their backs in all three of the larval stages. The following foreign species have been reported as being true trash-carriers: *Chrysopa ventralis* Curtis, *C. microphya* McLach. and *C. prasina* Burm. The known species having this habit in the United States are *Chrysopa lineaticornis* Fitch, *C. cockerelli* Banks, *C. lateralis* Guer., *C. bimaculata* McClendon, *C. bicarnea* Banks, *Allochrysa parvula* Banks and *Leucochrysa floridana* Banks.[2]

The packet of trash in these species is most ingeniously made. The materials, which are usually the same or very similar in the different species, are sufficiently interwoven and tied together to form a shapely hemispherical mass. It is laboriously constructed by the larva and repeatedly added to or repaired so that there are rarely trailing ends. The larva utilizes the materials of its surroundings to form these packets, thereby increasing any protective value. They consist chiefly of insect molts, dead insects, entire or only parts, fibers of both plant and animal origin, bits of bark, lichens, spiders' webs and other similar materials.

The larva either places small bits of these materials upon its back with the jaws, or it crawls under them and shifts them in place by body movements assisted by the jaws. The larva can bend its head posteriorly almost horizontally when the front legs are lifted. As pieces

[2] It has been found recently that *Eremochrysa punctinervis* McLach also belonged in this group. Reared larvae refused to take food until they had piled some trash on their backs.

are put in place, loose ends are gathered up by the jaws and tucked into the mass in such a way that it is considerably interwoven and compact. The materials are added only to the anterior portion of the packet. They are later pushed and shifted posteriorly so that when the larva is resting the entire abdomen and the greater part of the head and thorax are covered by this packet.

These larvae are well fitted morphologically to construct and carry these packets (Fig. 1).

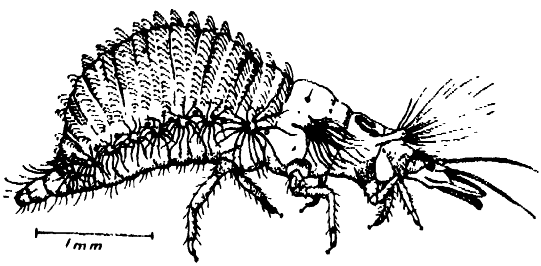

FIG. 1. Lateral view of a grown larva of *Chrysopa cockerelli* Banks—a rare species of Kansas and Colorado—with packet removed to show the long thoracic tubercles with setae arranged fan shaped, the short abdominal tubercles, the recurved dorsal abdominal setae and the shortened and humped abdomen.

The abdomen is much shorter and broader than in the non-trash-carrying larvae. The thorax or leg-bearing portion of the body is nearly normal for the family except that the stalks of the prothoracic and mesothoracic lateral tubercles are exceedingly long and each bears a group of upturned setae which extend outward like a fan. These setae support the anterior portion of the packet and allow for complete freedom of movement on the part of the thorax in locomotion. The lateral tubercles on the abdomen are quite small and bear short but stout setae. On the dorsum of the abdomen there are on each segment, from the first to the seventh, inclusive, one to three rows of minute or microscopical setae (perhaps the Angelhaare of Dewitz,[3] 1885), with recurved tips. Each, therefore, is a small hook which anchors this mass firmly to the back of the larva. The short, stout setae from the lateral tubercles also assist materially in holding the materials in place.

At rest, the larva contracts the thorax and abdomen somewhat, thereby bringing practically all the body beneath the packet. However, when it walks or runs, the head and a small part of the thorax, the tips of the first two pairs of legs and the end of the abdomen protrude from under the packet. The packet sways rather unsteadily from side to side such that photographing living larvae is most difficult.

These larvae are positively thigmotropic, as evidenced by their actions when the packet is removed. They run around excitedly and frequently endeavor to crawl under leaves, trash and packet materials. Furthermore, they are often found resting in crevices or irregularities of bark or under loose pieces of bark where their bodies are in close contact with the substratum.

Many writers have stated that Chrysopid larvae place the skins of their victims on their backs. While the impression has been frequently given that all Chrysopid larvae have this habit, some writers unquestionably observed the true trash-carrying habit. It is not possible to ascertain from the published accounts in every case whether writers observed the true trash-carriers, or whether they referred to larvae with merely a few aphid skins on their backs or sides. Nearly all the larvae have long setae or stout bristles on their sides and dorsum which may accidentally pick up such materials. The true trash-carriers, however, are only those larvae which carry the packets of débris upon their backs. There is no authentic published record of a Hemerobiid larva, or a "brown lacewing" larva, as now understood, being a trash-carrier. The known larvae of this family do not have the proper shape and morphological features which make this habit possible.

[3] Dewitz, H., Biol. Centbl., 1885, 4: 722–723.

The carrying of a few aphid molts or skins on the setae of the body is perhaps the beginning of the evolution of this habit. The skins are not necessarily placed on the setae by the larvae, but they catch on them as the larvae walk about. Further, the larvae sometimes search among these skins for food, or attempt to conceal themselves by crawling under them. They may adhere on any part of the body and are not constant in kind, amount or position. *Chrysopa oculata* Say and *C. nigrocornis* Burm. are typical of this group.

An intermediate condition in the evolution of trash-carrying is shown by *Chrysopa quadripunctata* Burm. Larvae of this species have the general coloration of our known trash-carriers, and they more commonly than others have skins and cottony filaments on their backs. But the trash is never in the form of small packet of constant form and appearance. These larvae are normally found on trees and shrubs. They are often taken among woolly aphids, certain woolly leaf hoppers and other insects with woolly coverings, so that even a few skins obscure them effectively.

The question at once arises: Is this rather elaborate construction and the activities incidental to it a real protection, or merely theoretically so? From the point of view of man, they sometimes make the larvae more conspicuous. A small piece of débris from two to eight millimeters in diameter moving across green leaves or on tree trunks is not only readily seen but excites the curiosity of even a casual observer. On the other hand, among woolly aphids they are difficult to distinguish. At rest they might be mistaken for loose masses of cottony materials or even bird droppings. These larvae, for the most part, live and search for their food in exposed places, as on leaves and tree trunks. Parasitism is low among them. The only parasites reared by the writer from trash-carriers were from larvae sent from the citrus groves of Florida. It has been reported that they are sometimes highly parasitized in California. No parasites were obtained from the northern species, *C. cockerelli* and *C. lineaticornis*. Lurie (1898)[4] pointed out that *Chrysopa septempunctata* is often parasitized, but in the trash-carriers, *C. prasina* and *C. ventralis*, parasitism is seldom found. So this habit apparently offers an appreciable degree of protection from parasites, but certain hymenopterous parasites, especially those whose larvae are leaf-crawling planidia, do attack them. They have not been reported as being eaten by birds, and the writer has not observed it, but it would be no surprise to find that titmice, creepers, nuthatches and birds with similar habits picked up a number of both larvae and pupae as they search for food on tree trunks.

The bodies of trash-carrying larvae are more delicate than the naked larvae. They appear semi-translucent at times and the epidermis is less chitinized. The packet serves as some protection from mechanical injury and from drying out as suggested by Lurie (1898). At least two species, *C. cockerelli* and *C. ventralis*, over-winter as larvae under or on the bark of trees. These coverings perhaps give some protection against the rigors of winter.

In the main, it therefore appears that the trash-carrying habit affords a definite degree of protection of one kind or another, as is usually stated, though there is little quantitative data supporting it. It is of especial interest to the naturalist, however, because it is, in present-day terminology, a familiar kind of camouflage.

[4] Lurie, M. G., [Russian title]. "The Biology and Life History of Chrysopa Leach." Univ. Warsaw. Studies from lab. of Zool. Dept., 1898, pp. 83–132.

PLANTATION RUBBER: ITS SOURCE AND ACQUISITION

By Professor FRANCIS E. LLOYD

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THE vast necessity for caoutchouc and the disturbing fact that there exists a "wicked monopoly" of the cultivated supply without the control of the United States of America, where by far the greatest bulk of raw rubber is consumed in manufacture, have aroused much interest in the tree that supplies this material and in the methods by which it is acquired. It is the purpose of this article to present briefly this information.

Of the many, many trees, shrubs and herbs which produce rubber (as caoutchouc has come to be called) only one has afforded a paying and satisfactory culture up to the present, namely, the Amazonian "seringueira," *Hevea Braziliensis*. Other Amazonian species contribute to the supply of wild rubber, a quality somewhat inferior to that of *Braziliensis* being afforded by *Benthamiana*, and still more inferior by others. Of these and several other tropical rubber trees, namely, "castilloa" (*Castilla* spp.), "ceara" (*Manihot* spp.), and "rambong" (*Ficus elastica*), which have been tried in cultivation, only *Hevea Braziliensis* has persisted. This will therefore be referred to shortly as *Hevea*.

Fifty years after the birth of the rubber industry, seeds were obtained in 1876 by Sir Henry Wickham from the Amazon region. The history of this adventure is not pertinent here, but it may be noted in passing that, had it not been for it, tires would cost now still more than they do. The seeds were sent to Kew Gardens, and from there seedlings were sent to Ceylon, which was the distributing point for further propagating material. This reached India and Burma, Malaya and Java, and ultimately French Indo-China, Borneo and even the Philippine Islands. Plantation rubber now hails from all these countries, by far the greater bulk (about 80 per cent.) being from Malaya and Netherlands India, in the ratio of two to one. The oldest trees under cultivation in the Far East are therefore to be found at Heneratgoda in Ceylon, and because of their historical interest two of these are here reproduced (Figs. 1, 2). One of the points to which the earliest distribution was made from Ceylon was the Botanical Garden at Singapore, where the writer photographed some of the original trees as they appeared in 1919 (Fig. 3). From this illustration we may see that there is nothing very striking about the tree regarded in the large. Mature trees in the forests of Brazil are no more remarkable. Young trees grown in the open soon acquire a well-shaped, rounded canopy of leaves (Fig. 4). They are of rapid growth, have a smooth bark—though a race with a decidedly rough bark is known—and branch rather freely and widely. The wood is brash and the tree is therefore easily damaged by wind. Tropical regions subject to strong winds, therefore, are not suitable for *Hevea*, however much so otherwise. When grown on plantations, where it occurs in immense plantings of uniform size, it produces an orchard-like effect of extreme monotony (Figs. 5, 6).

Commonplace as is the appearance of the tree, the leaves and flowers have characters which, to the eye accustomed to the verdure of temperate regions, do have something distinctive. The leaves are three-parted and of a glossy dark

FIGS. 1 AND 2. BOLES OF THE ORIGINAL HEVEA TREES PLANTED IN THE BOTANICAL GARDENS AT PERADENIA, CEYLON, IN 1876; PHOTO 1919.

green, with delicately tapering leaflets and characteristic venation. When young their pendulous position (Fig. 11) and pale color speak of tropical behavior. The flowers are individually inconsiderable, but, on the other hand, the inflorescences are large and widely spreading (Fig. 7). Of all the possibilities for the production of seeds as measured by the number of flowers, but few are realized. The difficulties of producing hand-pollinated seeds for the purpose of selection and improvement are very great. When pollination and fertilization are successful, the fruits produced are rather conspicuous. Each fruit is a three (sometimes four or five) lobed woody affair clothed with a green rind (Fig. 8) and having as many chambers as lobes. In each chamber is produced a seed. When approaching maturity the green rind dries and peels off (Fig. 9), and the woody portion in drying cracks into twice as many pieces as there are chambers, setting free the seeds (Fig. 10), which drop to the ground, together with the husks. If the reader has observed the fruit and seed of the castor oil plant, which are very similar to those of the related *Hevea*, they will enable him to visualize the latter. The irregular brown markings seen on the castor oil seed are seen here also. It is interesting to note that the arrangement and character of these markings (Fig. 10) are sufficiently characteristic of the individual tree so that the parent tree can be identified merely by careful inspection of the seed—a point of no small importance practically in the work of selection.

The seeds contain much oil—like castor oil seeds also in this—and they can not be dried and live. Respiration probably goes on at a rapid rate, and they are subject to attacks of fungi.

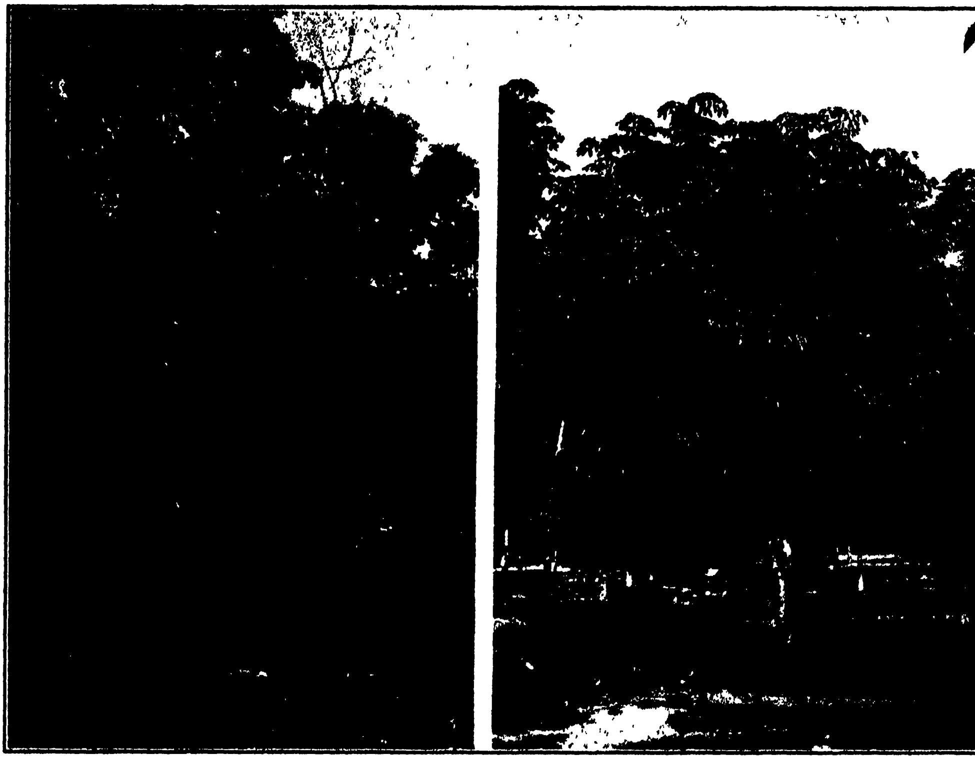


FIG. 3. THE ORIGINAL PLANTING OF RUBBER TREES DERIVED FROM CEYLON IN THE BOTANICAL GARDEN AT SINGAPORE; PHOTO 1919. FIG. 4. A YOUNG HEVEA GROWN ON THE SOENGEI BALEH ESTATE, SUMATRA.

They have, therefore, no great tenure of life. Normally they germinate at once; if prevented, they soon lose their vitality. It was this fact that made the acquisition of living material from Brazil difficult. Of 70,000 seeds obtained and sent to Kew, but a few (2,700) germinated, and the seedlings then had to be transported in toy greenhouses to Ceylon. Fortunately (from the Brazilian point of view unfortunately!) the trees develop very rapidly and in a very few years can produce a new crop of seed.

Once germinated, the seedling develops its first pair of leaves (Fig. 11) and then rapidly grows upward into a slender sapling (Figs. 12, 13). In starting plantations, the seeds are set out at once, or seedlings are grown in nurseries and then transplanted with various handling. A practice which has of late years been introduced and one which is bound to have an important effect on the yield is that of budding. Buds of high yielding trees are grafted near the base of seedlings of good stock grown in nurseries. After the bud starts, the stem of the sapling stock is cut off some distance above the bud. When the bud is well started, the transplanting into the field is done. Later, when the new plant shows signs of vigor, the superfluous piece of the stock stem is removed by a slanting cut near the growing bud. During the process of healing the wound is overgrown and eventually the joint practically disappears, though some distortion bears witness to the process for some time. Many problems of great theoretical and practical interest attach to this process. Grafting in general has had to do with

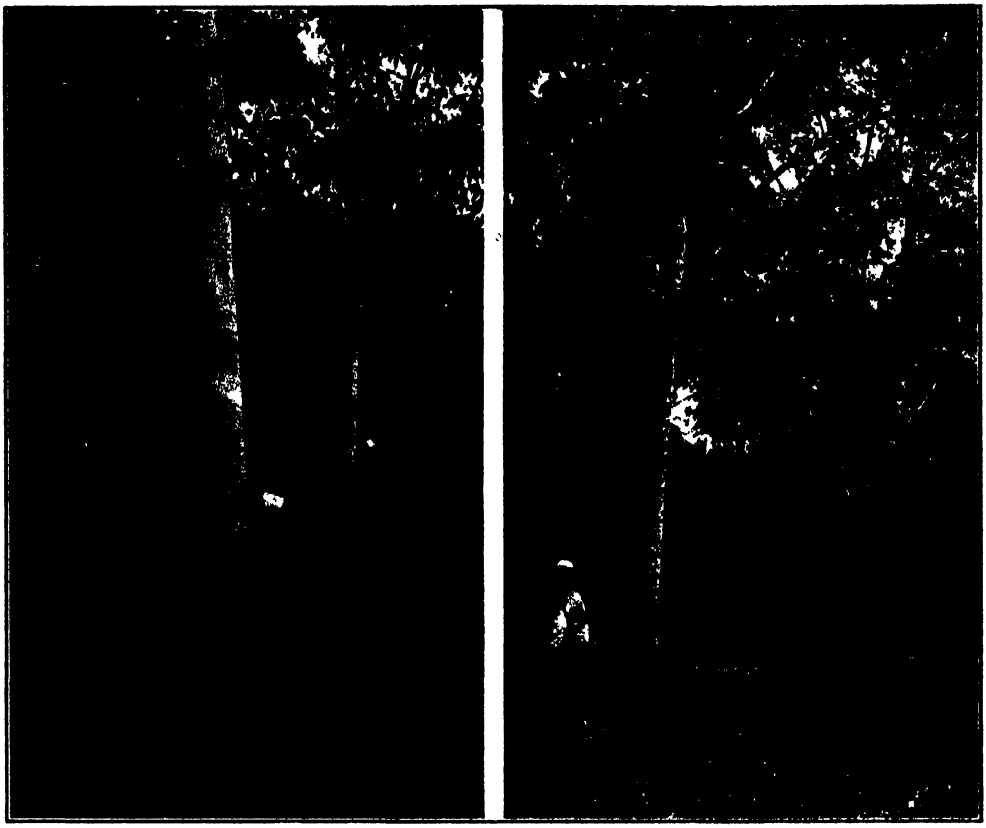


FIG. 5. TREES WHICH HAVE RECENTLY ARRIVED AT THE "TAPPABLE" SIZE, SUMATRA. FIG. 6. EIGHT YEAR OLD TREES, SUMATRA.

the production of improved varieties of fruits, and these are easily examined for qualities. It has been found, however, that the scions taken from a "good" parent are not equally good, and this bud variation has been the cause of disappointment. The rubber tree acts similarly, but it is much more difficult to test its good qualities—this can be done only after sufficient growth by a period of tapping, a process subject to much error. However, it has been done with promising results. These qualities are resident in the bark of the tree and the effect of grafting, with the necessary articulation of the bark of the stock with that of the scion, is problematical and only time will yield what it is wished to know.

Arrived at the age of about five years, the tree has become "tappable." Tapping is an operation requiring, to be understood, some knowledge of the structure of the bark. There is a rather widespread idea that it is like the tapping of a maple to get the sap, whereas it is entirely different. The sap of a maple is derived from the outermost layers of wood into which a boring is made and a spout adjusted to lead the dripping sap into a receptacle. The product of the rubber tree, called latex, is derived from the "bark" or cortex, beyond which no latex can be obtained. It would not only be useless but even harmful to cut deeper than the innermost layer of cortex. The rationale of tapping method will emerge from an

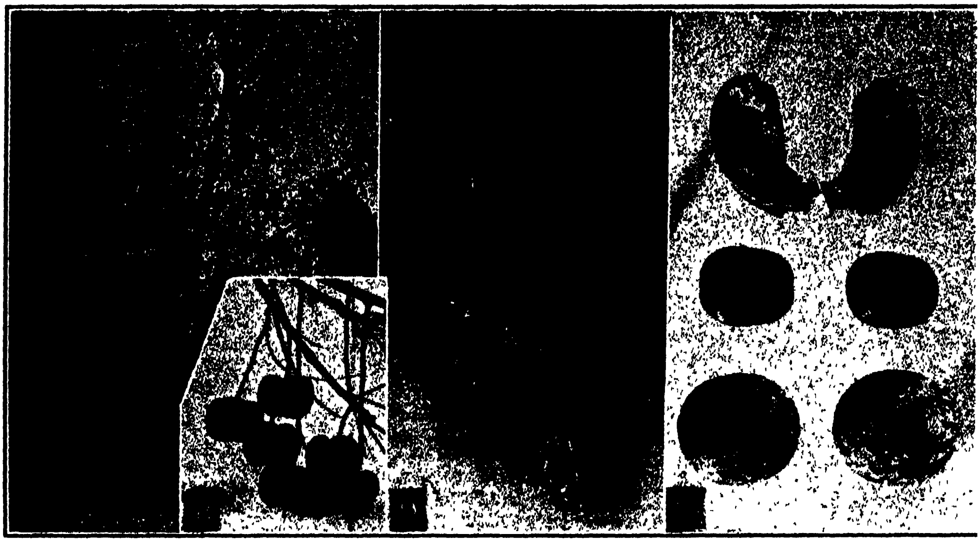


FIG. 7. BRANCH OF HEVEA, SHOWING THE FLOWERS. FIG. 8. RIPE FRUIT. FIG. 9. FRUIT READY TO BURST. FIG. 10. PORTIONS OF THE HUSK AFTER SPLITTING APART AND SEEDS FROM TWO DIFFERENT PARENT TREES.

understanding of the structure of the cortex, and particularly of the mode of occurrence of the latex. In an ordinary tree stem, the wood and the cortex are separated by the cambium, a layer of embryonic tissue which, by its own peculiar method of growth, gives rise on the inside to the wood, on the outside to cortex. The cambium, therefore, gives rise to all the various structures of the cortex, including of course those containing the latex, which are tubular and arise by the end-to-end fusion of short cells (Figs. 15, 19).

The total thickness of the cortex in trees upwards of ten years of age is about 8 mm. Examining a transverse section (Fig. 14) it may be noted that the outer zone is broken up by masses of stone tissue, similar to the hard fragments one notices in the flesh of a pear when eaten. These normally develop late and have the effect of making the bark hard and gritty. Moreover, their development breaks up the continuity of the latex tubes, which may be seen in regular ranks in the inner zone. This is obviously traversed by radiating tracts of cells, the medullary rays, which never contain rubber (see also Fig. 12, a, b). Elsewhere the latex vessels may be recognized because of their rather regular disposition in cylindrical ranks, in a transverse section appearing as circular rows. Each vessel communicates by anastomosis with a neighboring vessel (Fig. 15) so that the whole number of vessels form a network intercommunicating chiefly tangentially, but sometimes even radially. The number of ranks of latex vessels is a matter of great interest, since the amount of latex yielded must relate to the number of them, other things being equal. Other things, however, are not equal, so that the degree of correlation between yield and the number of ranks of latex vessels is only about one half the possible. For this reason the method of estimating the yielding power of a tree by counting the ranks of vessels does not work out.

It may further be observed that the ranks of vessels are generally closer together the nearer to the cambium, and

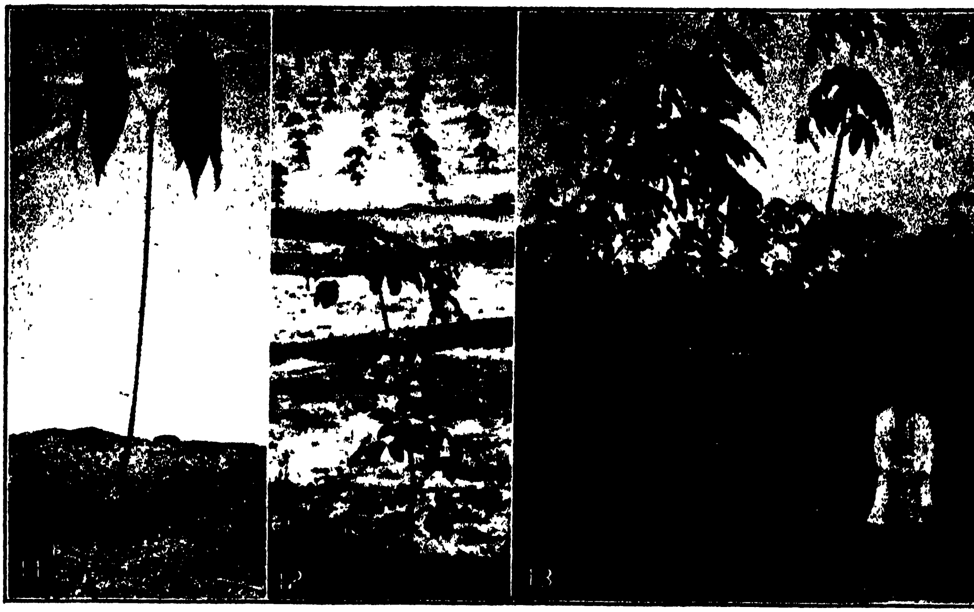


FIG. 11. A FULLY GERMINATED SEEDLING. FIG. 12. A YOUNG SAPLING. FIG. 13. SAPLINGS ABOUT ONE YEAR OLD.

often they come very close to it. The problem of tapping is to cut open these vessels transversely so as to let the latex ooze out and at the same time to catch it and lead it to an appointed receptacle. This is done by cutting a groove in the bark in such a manner that all the vessels will be cut across so that the latex will ooze into the groove, thus forming a channel down which the latex will run to a vertical groove, thence down a spout into a cup suitably affixed. The collecting groove is placed at an angle with the horizontal great enough to permit the latex to flow downward readily without overflowing (Fig. 21). The cutting is done with a suitable gouge.

The length and number of grooves and the frequency of cutting are all a matter of decision based upon conviction or economic strategy. The conviction may be arrived at by scientific investigation, which has culminated in finding that a cut half round the tree every day for a period (two to eight weeks), followed by an equal period of rest, is sometimes the most advantageous. Strategy, on the other hand, may dictate devastating methods, as happened during the rubber boom, when any method of getting all the rubber possible was held justified. They even climbed into and tapped the lower branches—"monkey tapping" it was called. Periods of market depression have an opposite effect. Looked at historically, the various methods of tapping afford an interesting chapter in the development of method. The original Brazilian seringueiro carried a small hatchet with which he made cuts in more or less haphazard fashion, fastening small tin cups so as to catch the flow. Recently there have been attempts at improvement by adopting more systematic cutting, following the lead of the eastern plantations. The seringueiro's method was at first employed as plantation practice in Ceylon, but soon gave way to a more careful grooving. As a result of the original method, the boles of long-tapped trees on the Amazon present a very pathological condition, due to the

FIG. 14. A THIN SECTION OF THE BARK MAGNIFIED.

irregular growths taking place during the healing process. The modern method of carefully grooving the bark, avoiding the cambium, but going as deeply as possible otherwise, and doing this evenly so that a smooth surface of young cortex is left, permits rapid and smooth healing. After allowing a sufficient period for this to be accomplished, the renewed bark is as smooth and healthy as the old (Fig. 21). This method permits the process of tapping to be repeated again and again at intervals of about four years, which is occupied in traversing the bark from the original tapping cut to the end of the available bark, thus bringing the tapper back to the starting point. All that is required to effect this is to lay out the available tapping surface into areas beginning at a certain height on the tree and tapping downwards at a given rate, *i.e.*, a shaving about one twentieth of an inch in thickness removed at each tapping—one and one half to two inches a month being the allowance. The thickness of the shaving must be sufficient to open anew the latex tubes, at the cut ends of which the latex coagulates, with the effect of plugging them. The operation must be done with no wounding, that is, without cutting through the cambium into the wood (Fig. 22).

The routine of tapping is as follows: The coolie gets out into the *keboen* just before the break of day. As soon as it is light enough (daylight comes on apace in the tropics) he begins to tap, cutting the fresh shaving and placing the cup in position by means of some contrivance like a *rotang* (rattan) sliver (Fig. 23) or a wire cincture (Fig. 5), cleaning out the grooves and tin spout of "scrap" rubber so that the latex will flow properly. This he (or she) continues till the stunt, so far as tapping is concerned, is complete. The coolie then goes the round of the trees a second time with a milk can into which the latex is poured. This is now carried to a central point, where the latex is passed through a sieve to remove dirt. The

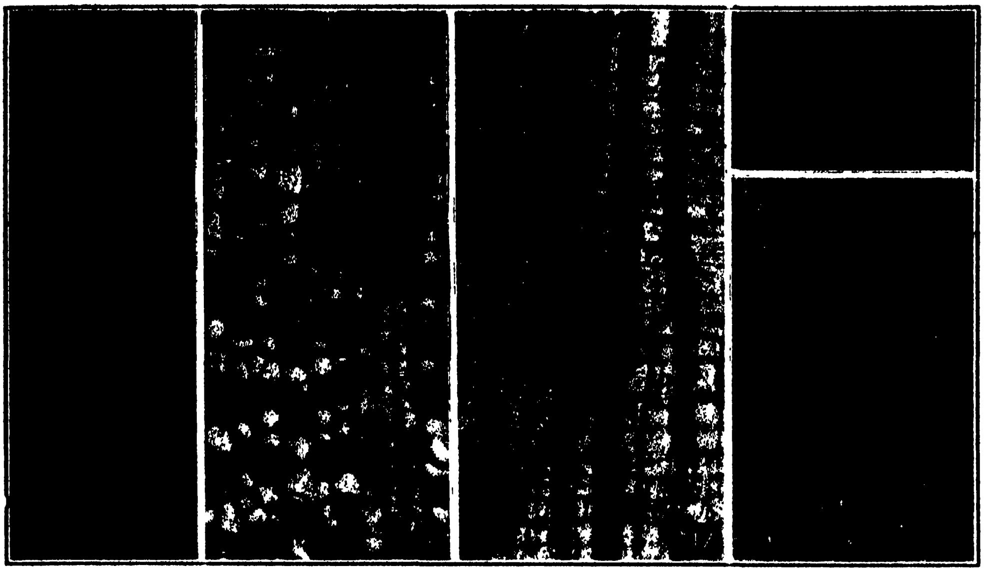


FIG. 15. TANGENTIAL SECTION OF THE BARK MORE HIGHLY MAGNIFIED SHOWING THE LATEX VESSELS ANASTOMOSING AND PASSING AROUND THE MEDULLARY RAYS. FIG. 16. TRANSVERSE SECTION SIMILARLY MAGNIFIED. HERE CAN BE SEEN A MEDULLARY RAY DEVOID OF RUBBER SEEN ELSEWHERE AS PAIRS OF VESSELS APPEARING DARK. FIG. 17. RADIAL SECTION OF THE SAME. THE LATEX VESSELS ARE SEEN THROUGH A THIN LAYER OF MEDULLARY RAY TISSUE. FIG. 18. TRANSVERSE SECTION OF THREE LATEX VESSELS STILL MORE HIGHLY MAGNIFIED. FIG. 19. THE SAME IN LONGITUDINAL SECTION. HERE THE INDIVIDUAL CELLS FORMING THE LATEX TUBE CAN BE DISTINGUISHED BY THE CONSTRICTIONS.

method of handling the latex so as to procure marketable rubber which has had long vogue is to pour it into tanks, acetic acid being added and wooden partitions being placed vertically at intervals so as to facilitate the removal of the coagulated rubber in slabs. These, on the following day, are passed through mills to press out the serum and to work them up into "plantation crepe" or sheets, which can then be hung to dry or be smoked, making "smoked sheet," an attempt to duplicate the original "up river fine" Pará, which is prepared by the seringueiro by coagulating the latex cupful by cupful, simply dripping it on a ball (*pella*) accumulated on a heavy stick or paddle, holding it meanwhile in a dense smoke of fire in which the nuts of the *Attalea* palm (preferably) are burnt. This process makes a black, smoky smelling rubber, the qualities of which, difficult to duplicate, have been supposed to depend wholly on the method of coagulation, contrary to the fact.

A new method and one which promises to be of increasing importance in the industry is that of spraying, carried on under patents obtained by Mr. Ernest Hopkinson, of the United States Rubber Company. It is not generally known that the first experiment leading to the working out of the method in its perfected state was done in the winter of 1918–19 at the instance of Mr. Hopkinson, with latex obtained in the New York Botanical Garden by the writer, and sprayed in a crude piece of apparatus designed for the trial. The perfected process consists in discharging the latex from a rotating horizontal disc at the top of a tower into which hot air is passed. The breaking up of the latex into minute droplets permits the rapid evaporation of the water, and the dried particles flocculate and fall to the floor of the tower like buff-colored snowflakes, whence the product is removed

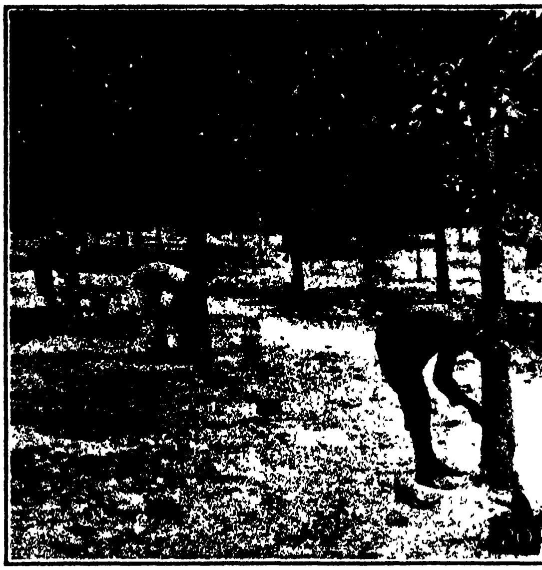
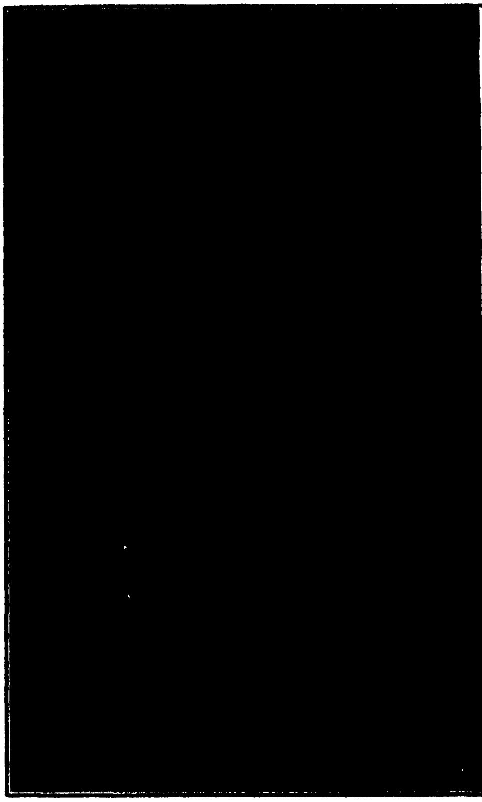


FIG. 20. COOLIES TAPPING AND COLLECTING LATEX FROM TREES WHICH HAVE JUST ARRIVED AT THE TAPPABLE AGE. FIG. 21. BOLE OF TREE WHICH HAS BEEN TAPPED ALL AROUND AND IS NOW BEING TAPPED FOR THE SECOND TIME. THIS TREE EXHIBITS NORMAL, CLEAN RECOVERY FROM THE TAPPING.

and compressed into suitable packages. It is to be noted that this method results in the formation of a coagulum containing all the original solids of the latex, whereas the usual plantations product lacks whatever remains in the serum, and this is not a little.

A word about the latex itself. This is a rather dense, usually white, milky fluid as it exudes from the tree, containing about 30 per cent. rubber. When viewed microscopically it is seen to be composed of a colorless watery phase in which are suspended myriads of minute droplets (emulsoids) of rubber about one micron in diameter, intermingled with many more water-containing suspensoids of other substances, chiefly proteins (Fig. 25). It is therefore a complex emulsion of probably more than fifteen kinds of substances, in considerable degree resembling milk, if we substitute rubber for butter fat. In the living tissues of the tree where it occurs this emulsion is normally stable, just as the blood in our veins is. If a wound is received, however, the oozing latex soon coagulates and forms a clot which seals the wound. In the older regions of the bark it coagulates, especially where the latex vessels have been broken up by the growth of stone cells. One of the conditions incidental to the diseased condition known as Brown Bast is the collection of masses of rubber in chinks in the bark. Characteristic of *Hevea* latex is the occurrence of rubber droplets which are pear shaped (Fig. 25). These are the largest of the droplets, and the shape indicates that they are not pure rubber, but a mixture. The pear shape appears to arise from the adhesion of two droplets of different sizes which are not miscible or are prevented from fusing by the interference of a third substance (a "protective" colloid), which procures a condition of low surface tension which stabilizes the couple. It is uncertain whether these pear-shaped droplets are not merely stages in the combining of smaller droplets. A similar, if not altogether analogous condition is to be seen in the large droplets, containing rubber, in the latex of the banana.



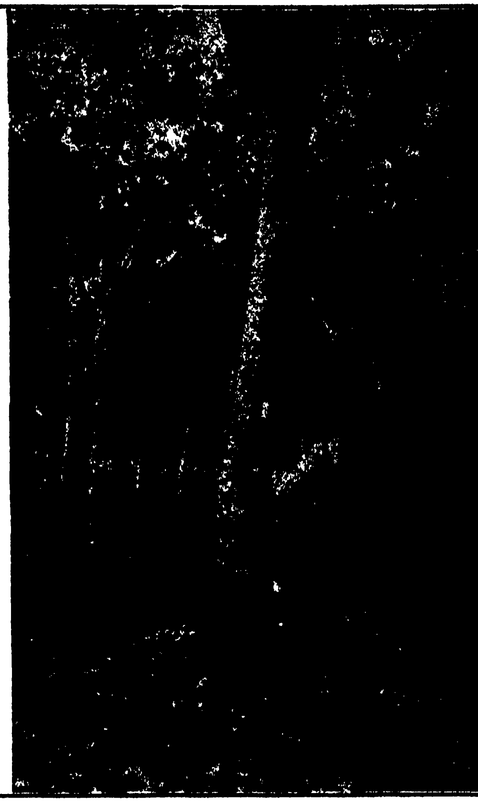


FIG. 22. A TREE WHICH HAS BEEN IMPROPERLY TAPPED AND IN CONSEQUENCE HAS DEVELOPED A LARGE AMOUNT OF YOUNG TISSUE CONSISTING OF WOODY EXCRESCENCES. FIG. 23. COOLIE RECORDING THE YIELD OF THE TREE BY CUTTING MARKS ON THE BARK.

Coagulation consists in bringing the caoutchouc droplets into contact so that this substance will now be a continuous phase (Fig. 26). To do this the protective action of the lyophile proteins must be overcome, and this can be accomplished by means of acids, alkalies having the opposite effect of stabilizing. The high viscosity of the rubber is an effective factor in obstructing the natural amalgamation of this substance into a continuous mass, so that milling is imperative to accomplish this rapidly, if coagulation has proceeded in a tank. After spraying, pressure alone may be used. Of course, when the raw rubber is used in manufacture it has again to be milled, but this matter goes beyond the present purpose.

The yield, that is, the amount of dry rubber per tree is, as may well be imagined, a matter of great moment to those who have money invested in plantations of rubber trees, since the cost of production is related inversely to this yield. By way of indicating the possibilities of different trees in this regard I may mention the performance of two out of a thousand carefully measured trees, comprising an observation plot on the estates of the U. S. Rubber Company, Kisaran, Sumatra (Fig. 24). In a given month these two trees produced 14.5 and 911 grams of dry rubber, respectively. Assuming one hundred trees to the acre, the yield from a population of such poor trees would be about thirty-five pounds, from the better two thousand two hun-

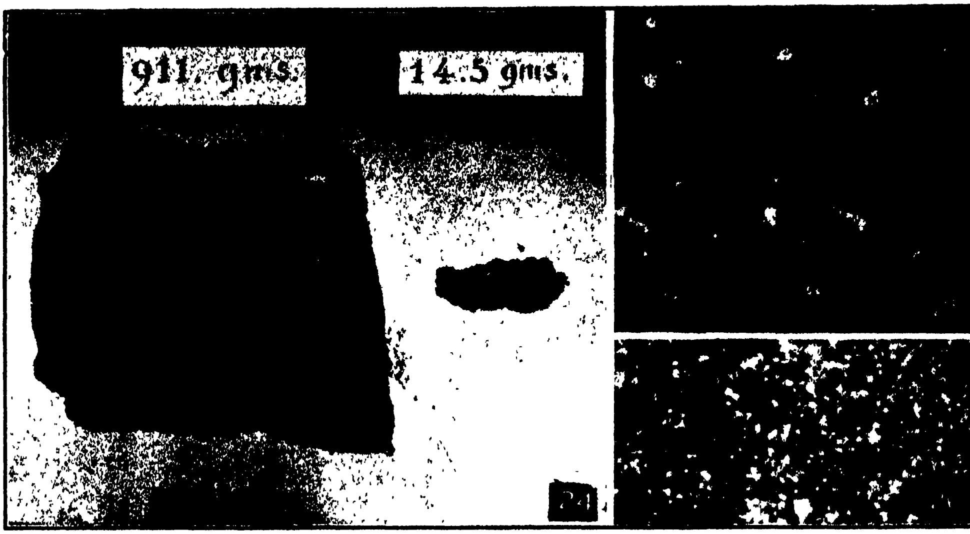


FIG. 24. THE ACTUAL COLLECTIONS OF RUBBER FROM TWO TREES SHOWING THE GREAT DIFFERFNCE IN YIELDING CAPACITY. FIG. 25. LATEX DILUTED AND VERY HIGHLY MAGNIFIED. THE PEAR-SHAPED AND ANNULAR FORMS ARE RUBBER DROPLETS; THE MORE SOLID SMALLER PARTICLES ARE PROBABLY PROTEINS. FIG. 26. COAGULATED RUBBER HIGHLY MAGNIFIED. THE BRIGHT POINTS ARE PROTEIN SUSPENSOIDS.

dred pounds! An average population produces three hundred pounds (or less) to six hundred pounds, according to the circumstances of the soil, rainfall, etc., but a flat average of four hundred pounds would be considered very good. In view of the individual differences it soon became apparent that selection was indicated. As above said, the production of seed is of such a manner that it is extremely difficult to obtain seed pollinated by a known male parent, though this has been accomplished in a meager way. Pending this achievement and the proving of the results thereby to be obtained, grafting methods have been employed, using for scions the material derived from individual trees having high records of actual performance in the matter of yield (Fig. 23) and as good stocks as possible.

For the purpose of selection it is imperative to judge by yield alone (Fig. 23), as it has been found that there is no character, not even that of the number of rows of latex vessels as above noted, which has a close enough correlation with yield to permit it to be used as a certain guide. It is of no little interest that the most persistent and rigorous use of scientific methods for this purpose, as also for the purpose of understanding the rationale of the best practice in tapping, soil management and other problems of growing rubber has been the work chiefly of the United States Rubber Company, although the British and Dutch Experiment Stations in the Far East had contributed a great deal to this end. With regard to yield alone it is not improbable that eight hundred to one thousand two hundred pounds of rubber per acre will be produced as a result of selection. That we are well on our way to this goal is an achievement of science well worth reflecting upon.

NOTE: The illustrations accompanying this article were taken—with obvious exceptions—on the U. S. Rubber Co. plantations, near Kisaran, Sumatra, east coast, all except figures 7-9, 12, 13, 20 and 23 from negatives by the author.

THE PROGRESS OF SCIENCE

By Dr. Edwin E. Slosson
Director of Science Service, Washington

PLANT GEOMETRY

All plants and animals are constructed out of little building blocks of a very similar sort. Each block is a cell, which, when fresh and living, consists of a tiny drop of jellied sap or juice enclosed in a thin-walled sac. Cut a thin slice of any vegetable or animal matter, put it under a microscope and you can see the individual cells. When free and separate they are round. When compressed together in a mass they form various flat-sided figures, mostly of four, five or six sides.

This suggests two questions. Why are the free cells round? What shape are the massed cells?

The answer to both questions is the same. The cells in both cases take the shape that will comprise the most substance in the smallest space. It is an instance of Nature's economy; an effort to make the cell-wall stuff go as far as possible.

It is easy to see why cells are spherical whenever they can be. They take that shape for the same reason as a bubble or balloon, a pebble or a marble. You do not have to mold a soap bubble or a rubber ballon. You just blow it up and it takes the shape that will hold the gas or hot air with the least stretching of the enclosing film. Put a lot of irregular fragments of marble into a barrel, attach the barrel to a water wheel so it will be kept rolling. By and by you will find that all the pieces of rock, however angular and knobby they may have been on the start, have been ground into the same form, a sphere. By rubbing against one another all their angles and prominences have been knocked off, and when you knock off all the corners and projections from anything you have a sphere. The pebbles and sand grains on a seashore have been ground down by friction into the same shape, which is the form that includes the largest amount of material with the smallest surface.

But when you mass the cells you get a different and more difficult problem, one in fact that has been a puzzle for more than a hundred and fifty years. For when you pack together a lot of spheres, say shot or oranges in a box, you find that they do not fit together but leave waste space in between them. Each sphere, except those on the outside layer, is in touch with twelve others. You can see this by putting a pea on the table top. You will find that it takes six others to form a ring around it. On top of the group you can set three others, and of course three more could find place below it. If then you should compress a bunch of spheres the twelve points of contact would become flat faces, and when all the empty space was squeezed out the interior spheres would all become twelve-sided figures. Buffon, the great French naturalist of the eighteenth century, tried this experiment by packing dry peas in a jar and then soaking them with water till they swelled tight together. Experiments with masses of bubbles confirmed this twelve-sided shape as an economical form. Of the twelve faces six are tri-

DR. GASTON RAMÓN,

OF THE PASTEUR INSTITUTE, PARIS, KNOWN FOR HIS WORK ON DIPHTHERIA ANTITOXIN, WHO IS SAID NOW TO HAVE DISCOVERED A SERUM PROVIDING IMMUNITY FROM TETANUS, AND HIS ASSISTANT IN THE DISCOVERY, DR. CHRISTIAN ZOELLER, OF THE MILITARY HOSPITAL OF VAL DE GRACE, IS SHOWN STANDING.

angles and six are hexagons. The honey-bee uses this form for its comb.

But Lord Kelvin, the great English physicist of the nineteenth century, found that space could be filled compactly and with less sacrifice of the spherical form by a more stable figure having fourteen sides instead of twelve. And now Dr. F. T. Lewis, of the Harvard Medical School, after many years of study, finds that vegetable and animal cells generally tend to take this fourteen-sided figure. He has mapped and measured with the microscope consecutive sections of various tissues, such as elder pith and human fat, and then constructed large wax models of the cells that would account for the observed contacts. They are very irregular and differ in the number of their flat faces because they get distorted by the pressure of their selfish neighbors, but can be best regarded as all derived from this fundamental fourteen-sided form.

I say "fourteen-sided form" because I hate to use the proper geometrical term for it, the tetrakaidecahedron. But the figure itself is not so ungainly as its name as you will find if you cut one out of soap or mold it out of putty. Eight of its faces are hexagons and six are squares. There are thirty-six edges where two faces intersect and twenty-four corners where three faces intersect. Such figures fit together as prettily as a Chinese puzzle, each in touch with fourteen neighbors. It is worth while getting acquainted with it since it is the pattern approached by the twelve thousand million cells that constitute your skin, as well as incalculable myriads inside of it.

LEARNING FROM BEES

"COME into my office and see my beehive," said Professor Hover, of Ypsilanti Normal.

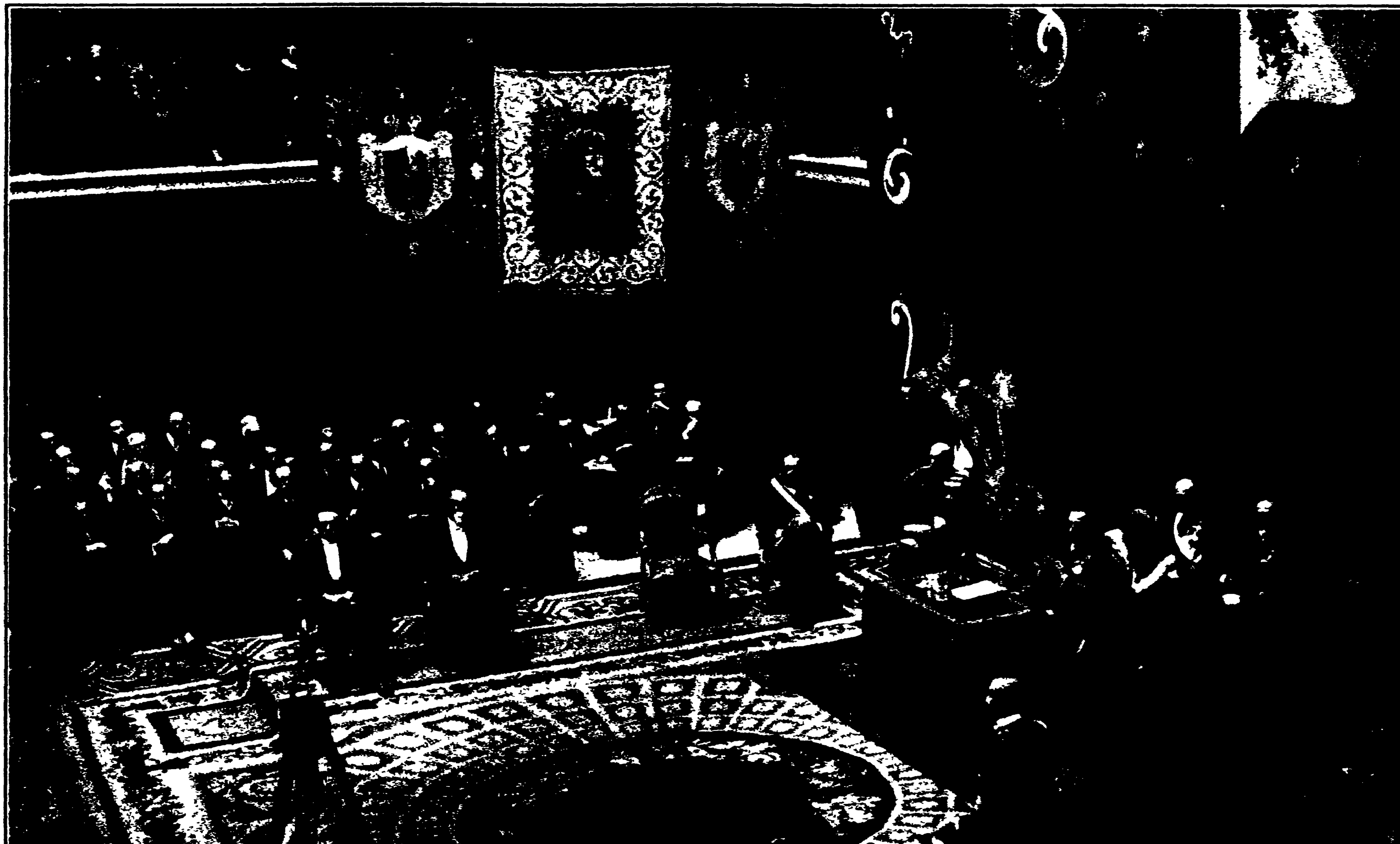
"What do you have a beehive in your office for?" I asked.

"So I can tell what the bees are doing all day long."

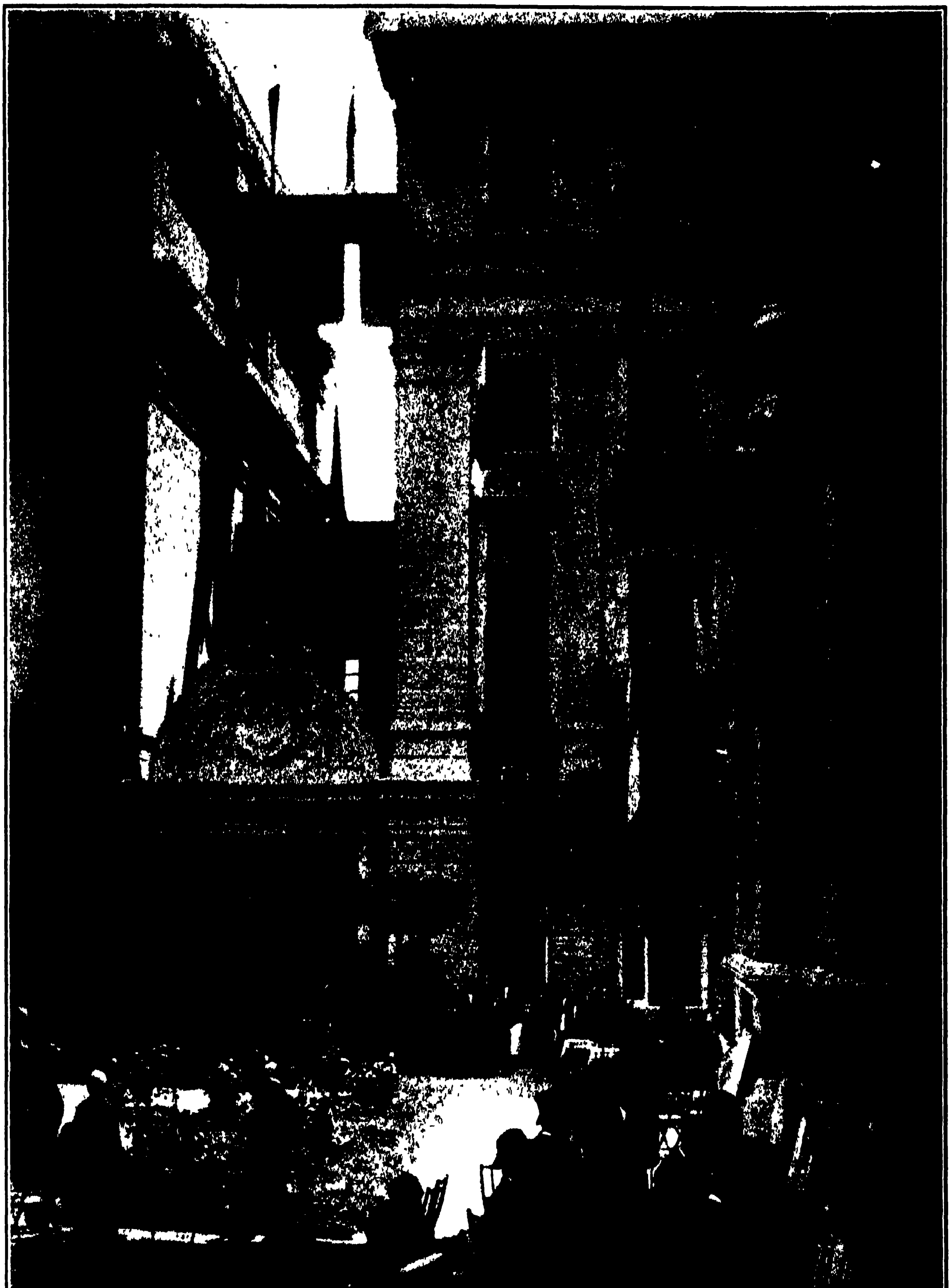
I protested: "Your bees are not acquainted with me. They may not like me at first sight. Sometimes bees don't."

But he went on into the office and I cautiously followed. Then I saw it was safe, for the bees had been provided with a private side entrance like those in apartment houses marked "For Servants and Tradesmen." In the window was a little hole leading to the hive which was ingeniously balanced on a scale so that its weight was automatically recorded. The temperature, barometric pressure and percentage of sunshine were recorded simultaneously. All these records were copied by the students in comparative graphs on a big chart covering one side of the classroom, so they could follow the movements of the bees and the changes of the weather from day to day and from month to month. And they had marked on the chart at points where the curve made a sudden jump such explanatory words as "white clover" or "alfalfa," indicating the date of a spring opening or midsummer bargain day. This experiment, you understand, was a "rural nature study course," one of those newfangled "project" schemes that have made education so much harder than it was when I went to school. For now they use books less and brains more. They study the thing they are studying, instead of merely reading about it, as we used to in the good old days.

But it was more interesting to look at this chart than to read any book on the subject, even Maeterlinck's "Life of the Bee," or Dunsany's play "The Flight of the Queen." For the curve was a continuous census and balance of



THE FOURTEENTH INTERNATIONAL GEOLOGICAL CONGRESS
BEING OPENED AT MADRID BY THE KING OF SPAIN.



THE NEW BUILDING OF THE GEOLOGICAL INSTITUTE OF SPAIN
IN WHICH THE SESSIONS OF THE FOURTEENTH INTERNATIONAL GEOLOGICAL CONGRESS WERE HELD.

trade. We could count the bees by the pound as they entered and left, and measure their exports and imports.

On a sunny morning there is a drop in the weight of the hive of about two pounds between eight and eight-thirty. This means that some ten thousand bees have sallied forth on their first foraging expedition. A quarter or a third of the inhabitants of the hive have left for their distant field of labor. Soon they begin to return with their booty and the weight gradually gains five or six pounds during the day.

But in the middle of the afternoon when the sun shines there is a sudden slight fall in the curve. This is due to the daily frolic of the debutantes. The young bees, some two thousand of them, go out for a trial flight. At first they keep close so as not to lose their way. heading in and hovering only a foot or two away from the door of the hive. After a half an hour of open air exercise they return to their domestic duties.

Another series of daily drops in the spring is of more sinister significance, for there is no recovery in this curve. It is due to the death of the old bees. The first warm days tempt them out, but they have not strength to make the trip so they die in the path of duty, five or six hundred a day.

At sunset the bees return and the hive is at its heaviest, for during the night it loses continuously due to the evaporation of the water from the nectar. This contains about seventy per cent. moisture as the bees bring it in, and this percentage has to be reduced to about fifteen for honey. So the bees fan the surplus water away with their wings, sometimes getting rid of two pounds of it in the course of the night by their very vigorous and efficient ventilating system.

One of the notches noticed on the chart remains a puzzle to me. About fifteen minutes before rain breaks the bees come homing to the hive. A pound and a half of them, over seven thousand bees, will pour into the hole in ten minutes, looking like a living funnel, a cyclone of insects, the swirling swarm getting thicker and narrower as the entrance is approached. Now, since this home run begins before the first raindrops, how do the bees know it is coming? Is it the cooling of the air, the falling of the pressure or the shutting off of sunshine that warns them of the approaching storm? Even the professor did not profess to know, but he hoped he might if he kept on studying his office hive. That is one of the advantages of this new-fangled method of education, even the professors learn something.

AVIATION AND THE UNIVERSITY

By Professor Alexander Klemin

Daniel Guggenheim School of Aeronautics, New York University

The pioneers of the early days of aviation were generally men of an original, adventurous type of mind, possessed of great native ability, but not of a formal scientific or engineering education. The Wright brothers themselves, while well-educated men, who conducted their experiments in a most systematic and scientific manner, did not owe their success to inspiration drawn from the professors of a university or a technical school. For radical departures from the beaten track in engineering a burden of learning may sometimes be a handicap. At any rate we have in mind the name of a famous astronomer, Simon Newcomb, who proved that aviation was impossible, and the sad case of a young Yale in-

structor in physics, Edson F. Gallaudet, who was told that his experiments with a very likely model of an airplane, conducted approximately in 1893, might be the justifiable cause of his dismissal from the faculty.

But when once the radical departure has been made, certain rudimentary principles established, the need for accurate scientific experimentation follows immediately. The early pioneers tend to drop out of the ranks, and the burden of progress is carried on by more rigorously trained men. This is the case in aviation at any rate.

As the body of information grows larger, formal instruction at the universities becomes imperative.

Thus in aviation, or more broadly speaking in aeronautics, many universities in Europe and three or four in the United States are now giving systematic courses of instruction in aeronautical engineering.

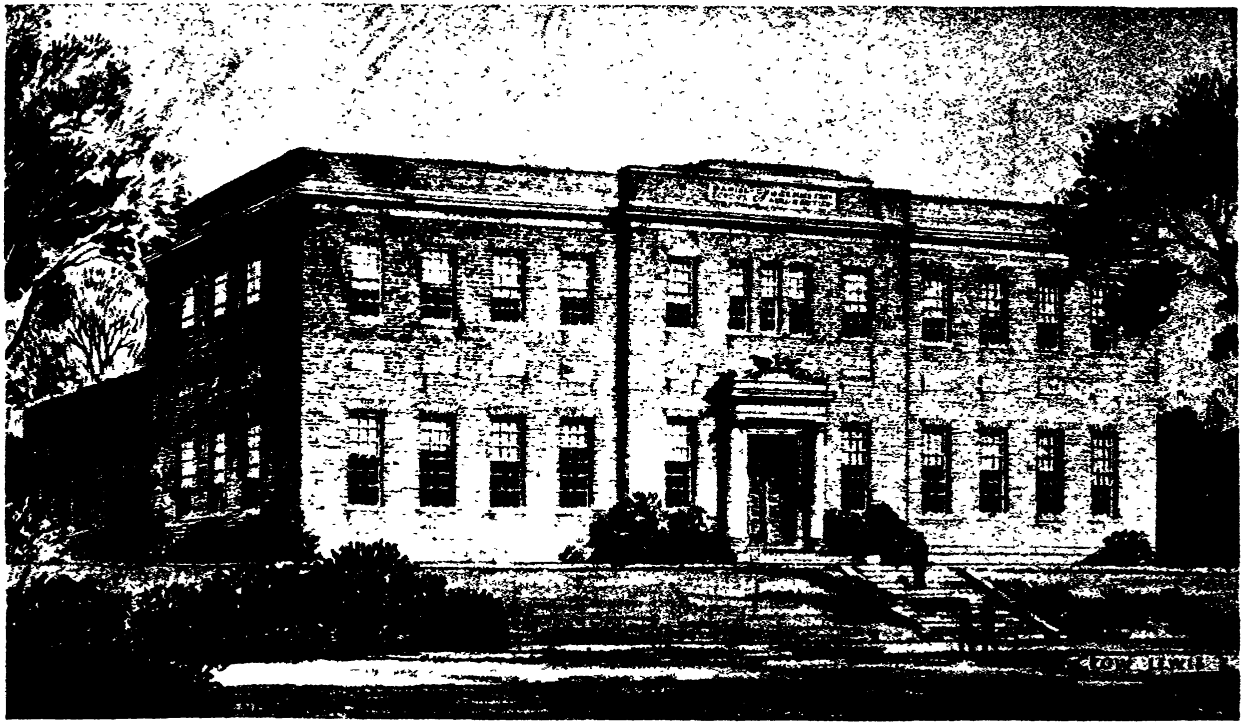
At the Daniel Guggenheim School of Aeronautics at New York University, brought into being by the munificent gift of $500,000 by Mr. Daniel Guggenheim, students who have received a grounding in mathematics, mechanics and mechanical engineering apply themselves in their senior year to the systematic study of such subjects as aerodynamics, airplane design, structural analysis of aircraft, the dynamics of aircraft and related subjects. It is their privilege to work in the wind tunnel where small models placed at the throat of a giant Venturi provide accurate bases for the prediction of aircraft behavior in the air. The destruction tests of wings, wing ribs and other structural parts provides the training in strength considerations as applied to aircraft which means so much to the safety of our pilots. From being the child of intuition of a few bold spirits, the airplane has become the carefully calculated and tested product of one of the most scientific and mathematical branches of engineering. Progress in aerodynamics at least is now most likely to come from careful research in the wind tunnel, with plenty of scope for teachers and postgraduate university students alike.

There is, however, one aspect in the training of aeronautical engineers which must not be neglected. And that is contact with reality, and in this instance flight itself.

Fortunately aeronautical engineering is intimately connected with the problem of national defense. In the rapidly developing air service, it is an advantage to have in the reserve personnel men who have had a formal aeronautical engineering training. For the young aeronautical engineer, it is a tremendous advantage to be in contact with the duties of the air service officer, to carry out flying missions, to learn that the airplane actually flies and is not merely a mathematical abstraction. It would be a sorry automobile produced by a man who had never sat behind a steering gear, and a wretched airplane designed by a man who had never felt a "joy-stick" in his hands.

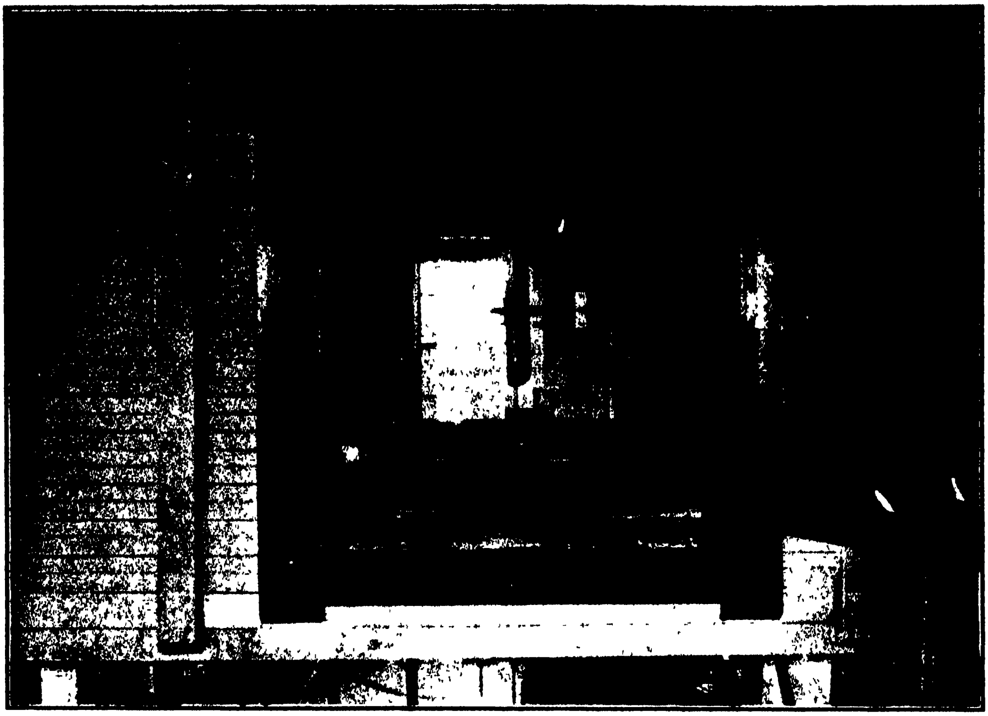
The recent establishment by the War Department of an aviation unit at New York University serves a double purpose therefore, and is a matter of congratulation to university and air service alike.

In their freshman and sophomore years students follow the general system of instruction in the Reserve Officers Training Corps. If their merit warrants it, and the professor of military science approves, students may then enroll in the aviation unit. They receive some theoretical, but mainly practical, instruction in airplane motors, airplane rigging, gunnery, instruments, meteorology, aerial navigation and tactical observation. Six weeks of the junior summer session are spent in camp at a regular army flying field. Under the supervision of air-service officers, the cadets



THE DANIEL GUGGENHEIM BUILDING

IN THE SCHOOL OF AERONAUTICS, RECENTLY ESTABLISHED AT NEW YORK UNIVERSITY



MODEL OF AIRPLANE BEING TESTED IN THE WIND TUNNEL
WHERE IT IS SUBJECTED TO RAPID CURRENTS OF AIR AND WEIGHED FOR ITS QUALITIES IN FLIGHT.

conduct reconnaissance, artillery adjustment, infantry liaison and various other missions as flying observers. At the successful completion of this course, the young men are eligible for commission as second lieutenants in the air service and can then continue their training as flight officers.

The plan is but another instance of the useful cooperation which may exist between the university and the instruments of our national defense, and a particularly important instance because aviation bids fair to surpass even the other arms in utility.

THE PROFESSOR OF GEOLOGY CITES AN INSTANCE

By Gilbert Oakley Ward

His name, said the professor, call it Schultz.
He came of what you'd call intelligent stock.
Father, a preacher (evangelical);
Himself, a keen and conscientious student.
More curious, I found him that rare bird,
A born field naturalist. One day in class
I passed about the tooth of a dinicthys.
What does he do but clap it on his notebook
And trace an outline. 'Twas a little thing,
But not another man had wit enough
To think of it.

But rocks and fossils offered
Too small a scope for his inquisitive mind.
Still driven by his instinct to the field,
He added to his course, zoology,
Brought to it all the penetrating eye,
The hunger for detail, the sense of order
That marked him of the elect.

So, for four years
He studied Genesis engraved in rock,
Ground over modern texts and living species,
Exposed himself to all their implications,
Rubbed against fellows doing real research,
And breathed the latest biological thought,
As you might say.

Well, sir! I told the boys
To buy a certain book on evolution
(This happened, mind you, in his senior year!)
And Schultz right then and there walked out and quit;
Declared he took no stock in evolution!
Exactly so! Laid back his ears and balked
Just like a mule.

A few days after this
We met one morning in a corridor
And stopped to chat a moment. Apropos,
He spoke of evolution and observed,
"No modern scientist takes seriously
The evolution theory." And I—
I was too dumb struck even to ask him how
He got that way.

I'd give a deal to know.
I've sometimes wondered if a fear complex
Buried down deep, a sort of mental sieve
Woven perhaps of dark sectarian crotchets,
Screened out unwelcome, non-conforming facts.

No, sir! I feel it isn't ignorance
A college often wrestles with to day,
So much as a type of mind. . . .

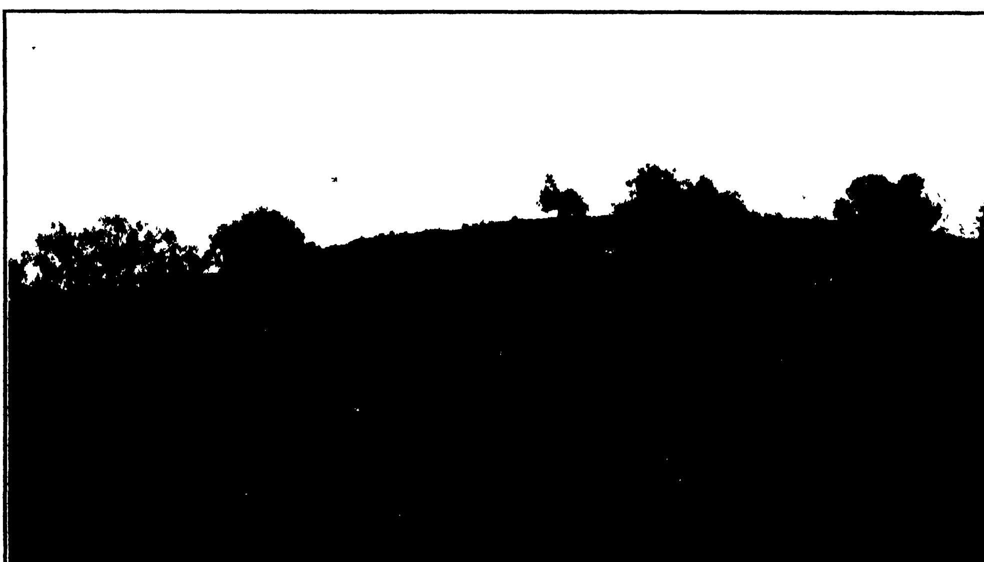
THE SCIENTIFIC MONTHLY

OCTOBER, 1926

CUICUILCO AND THE ARCHAIC CULTURE OF MEXICO

By BYRON CUMMINGS
TUCSON, ARIZONA

IN April, 1922, the writer, in company with Dr. Manuel Gamio, then director of anthropology in the Mexican government, visited a hill near San Fernando in the Federal District of Mexico which is surrounded by a lava flow known as the "Pedregal." There were some slight indications that the hill was not natural but was a ruin so old that time had obliterated all trace of its existence except this pile of rock covered with trees and overgrown with grass and brush. But here was a mound up whose sides had crept waves of black flinty lava that held the hill in a vice-like grip and sealed everything beneath from curious eyes. If it should prove to conceal a ruin, we had something here that might throw much light on the archaic culture of the Valley of Mexico. The venture appealed to the writer, and Dr. Gamio gladly assented to the request for permission to excavate there. The Mexican government furnished some men and the work started. Nine months were spent there through cooperation between the Mexican government and the University of Arizona. In July, 1924, the work



CUICUILCO BEFORE EXCAVATION.

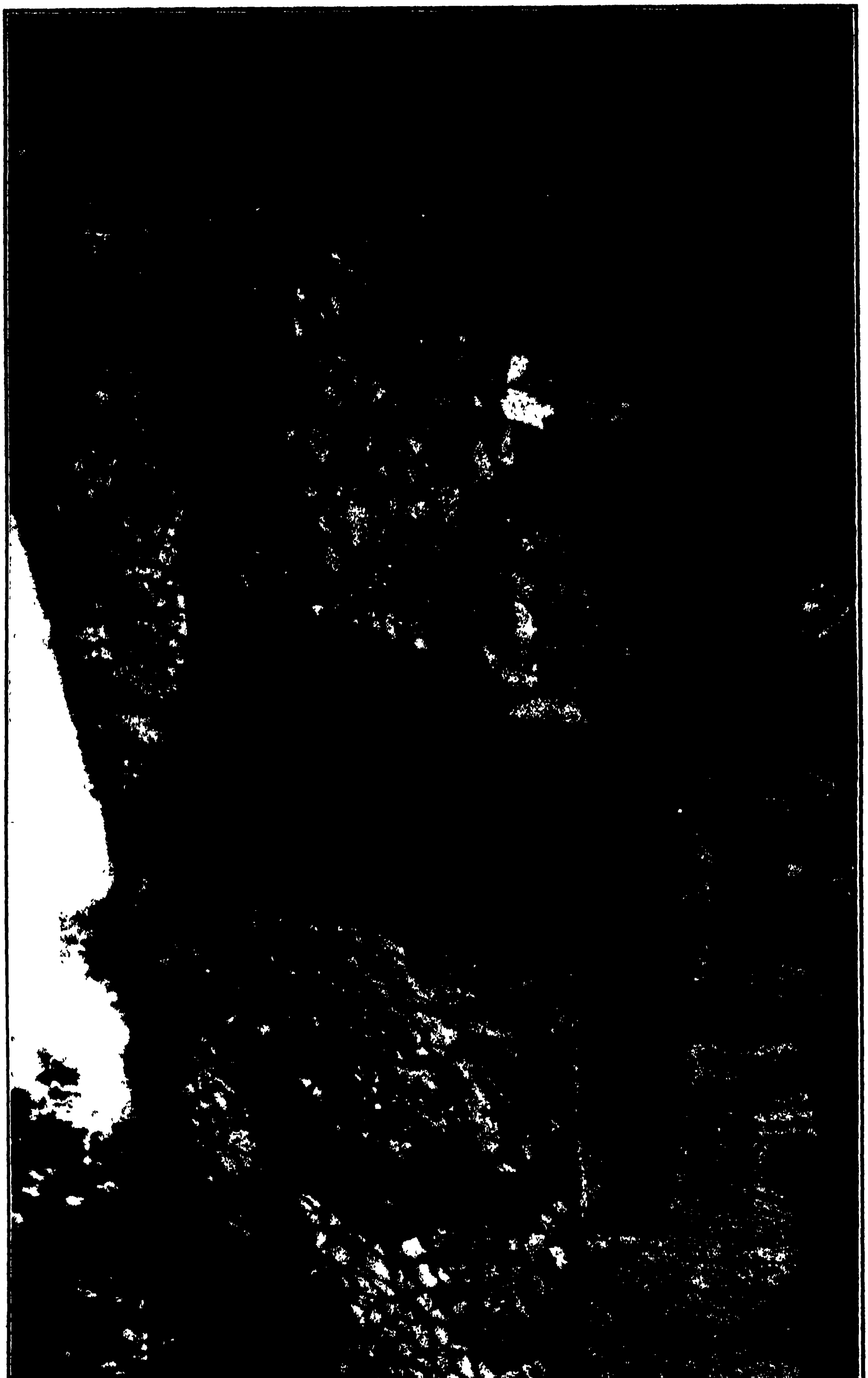
BLASTING AND REMOVING LAVA FROM THE NORTHEASTERN SLOPE.

UNCOVERING THE SOUTHEASTERN SLOPE.

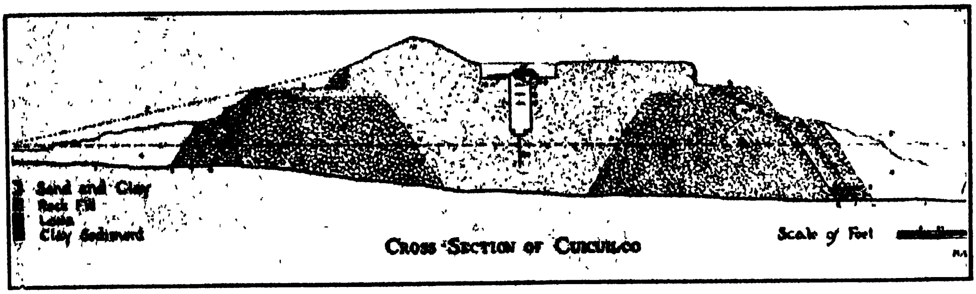
was resumed under the auspices of the National Geographic Society, the Mexican government and the University of Arizona and continued until September, 1925.

The mound proved to be an old temple built in the form of a truncated cone, with a diameter at the base of 387 feet, and at the platform of 291 feet, and a height of 74 feet. A cone of rock erected on this platform raised the total height to approximately 90 feet. The base lies buried beneath from 25 to 33 feet of clay, rock and lava, and the original top platform is covered with 18 feet of accumulated sand and clay and of clay and rock of later construction.

It was built like a great circular rampart of loose rock, with a central filling of clay and sand. This stone rampart is 70 feet wide on top and covers almost the entire area on the bottom. It is built of irregular chunks of lava thrown together and the holes filled with smaller pieces. The outer surface wall consists of large chunks of lava fitted together with some care at an incline of an average of forty-five degrees. The inner ends are bedded in smaller pieces of lava and the wall thus rendered quite compact and solid; but none of the stone has been surfaced in any way and there is no mortar or filling material of any kind, except the small stone. In the rock



THE OLDEST EASTERN ENTRANCE.



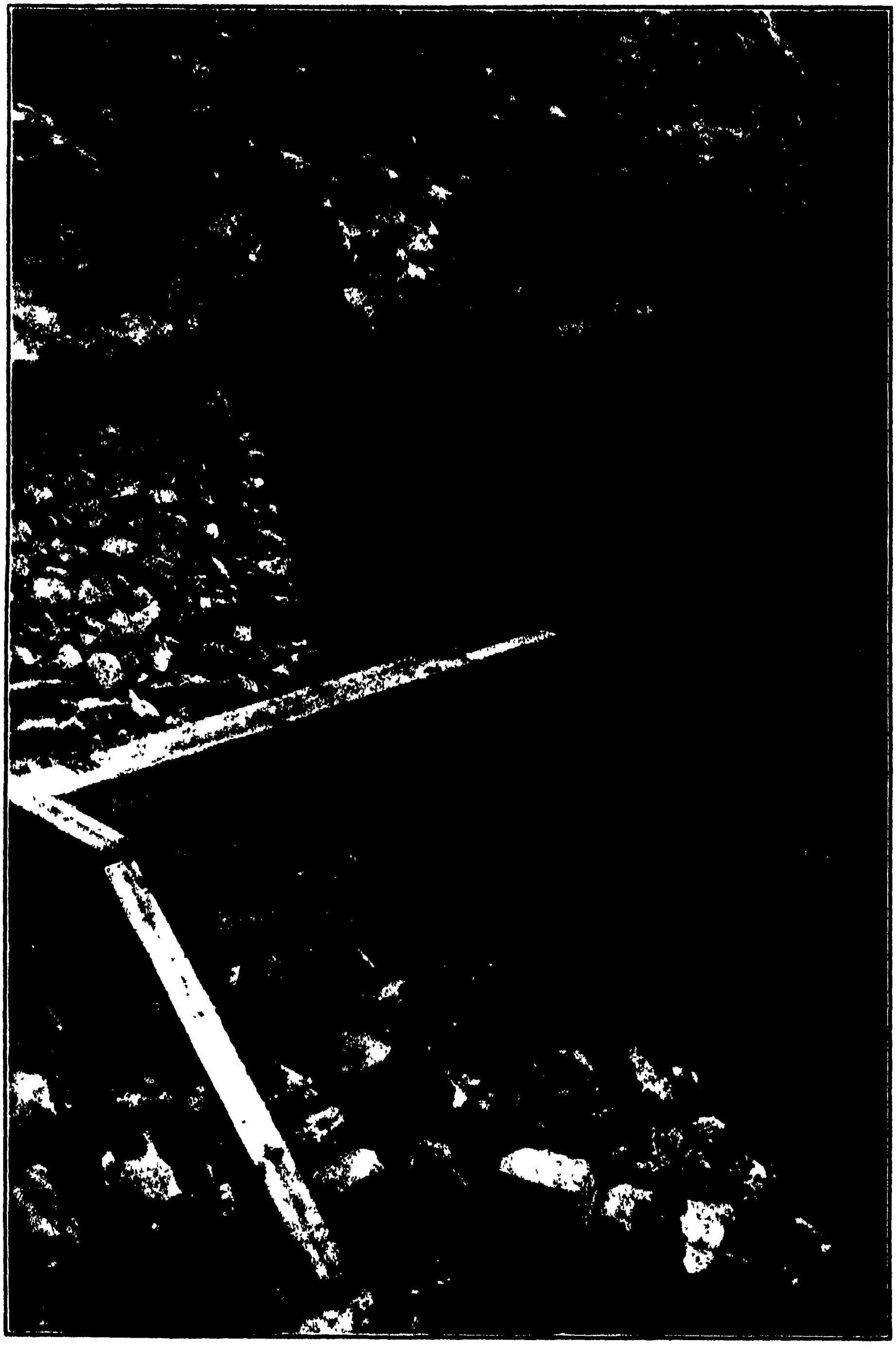
PROBABLE CONSTRUCTION.

UNCOVERING THE TOP OF THE TEMPLE. SHOWING CROMLECS SURROUNDING

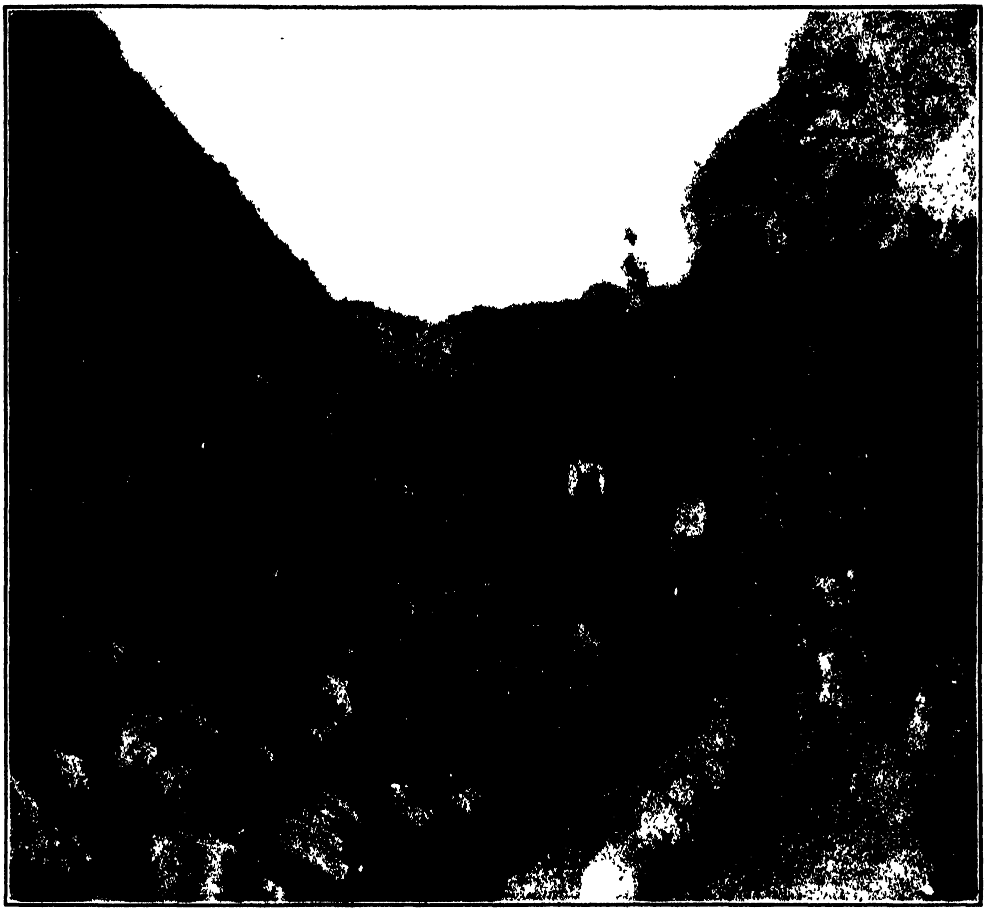
portion of the top platform, the cracks and holes were filled with small stone and then the whole covered with a layer of clay that had been packed down by the tread of many feet.

Extending away from the structure two degrees north of east was an inclined causeway 86 feet wide. The rock fill behind the northern wall is 28 feet wide and behind the southern wall 16 feet with a central filling of clay 42 feet wide. This ascending causeway led from the surrounding plain to the bottom of a low incline made of huge boulders that led to the original platform. This boulder incline has a width of 33 feet and a height of 27½ feet, and this is the only approach to a stairway found in the entire structure. It requires very little imagination for one to see a gaily decorated procession of ancient tribal priests slowly mounting that long incline and stepping from boulder to boulder up that last ascent to the great dancing place on top. Here they formed and faced the east to catch the first rays of the Sun Father, as he sent his rejuvenating light and heat upon the haunts of men. Can you not hear their glad acclaims as they move in joyous harmony to their tum, tum! tum, tum! and chant their prayer of welcoming thanksgiving to their All-Father?

From the western side extended slightly to the south of direct west another inclined plane leading from the



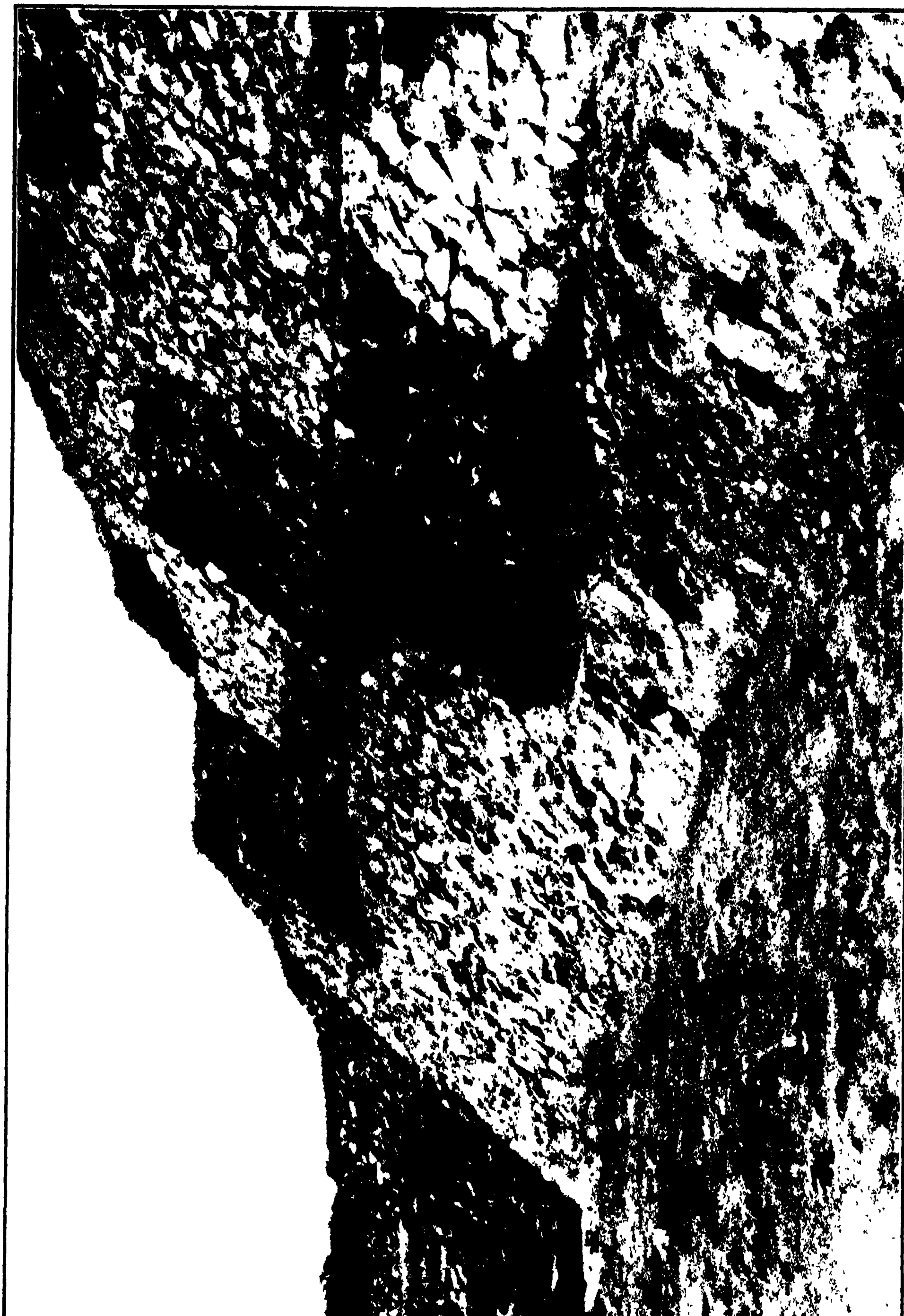
TUNNEL BENEATH THE LAVA ON THE EASTERN SIDE. THE TIMBERS ARE 16 FEET HIGH.



THE EASTERN SLOPE BELOW THE LAVA.

top platform out some 150 feet from the base of the temple. This grand approach was 45 feet wide. The sustaining wall with its rock fill behind it on the south side was 8 feet and on the north side 6½ feet, leaving a clay fill of 30½ feet. On the north side of both the eastern and western approaches the causeways have been widened by the addition on the western side by three walls, respectively 12, 14 and 6 feet in thickness, and on the eastern side by two walls each 6½ feet thick. It would seem that the great force of inundations and floods had swept in from the northern side and necessitated the reenforcing of these projecting northern walls to prevent the undermining of their bases and the sweeping away of the great approaches.

After the original temple had been used for some time, a later chief desiring to make a better impression upon the gods and demonstrate to his people the superior power and favor he was receiving direct from heaven, enlarged the earlier structure by building a wall 10 feet thick at the base and 6 feet thick at the top outside the original surface. The top of the first wall had been injured somewhat and fallen into ruin as evidenced by the repair work that had been done along the upper edge of the first structure. These walls were carried a



FROM THE SOUTHWEST.

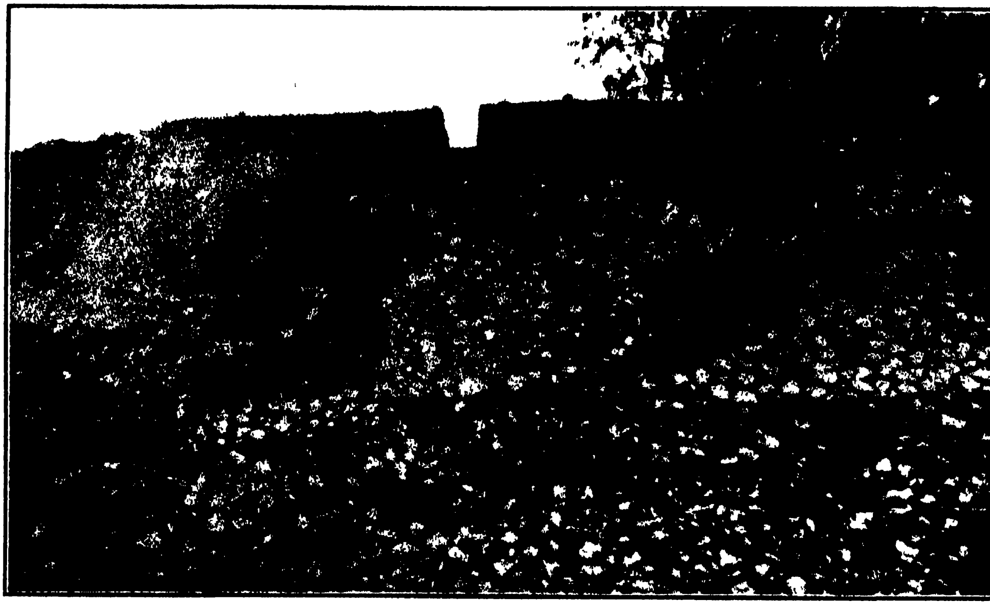
little higher also and the platform correspondingly raised by filling the central section with earth. At the center of the original platform was a raised altar made of hard packed clay that had been painted a deep red. When the temple was enlarged and the platform raised, another altar was made directly above the first and painted red in a similar manner.

Some later big high priest and chief, not to be outdone by his predecessors. enlarged the temple again by another outside wall averaging about the same thickness as the first enlargement, namely: 10 feet at the base and 6 feet at the top. The platform was again raised and a new altar built. Thus generation succeeded generation and century followed century and still the old temple reared its great dancing place above the surrounding plain, the tribes

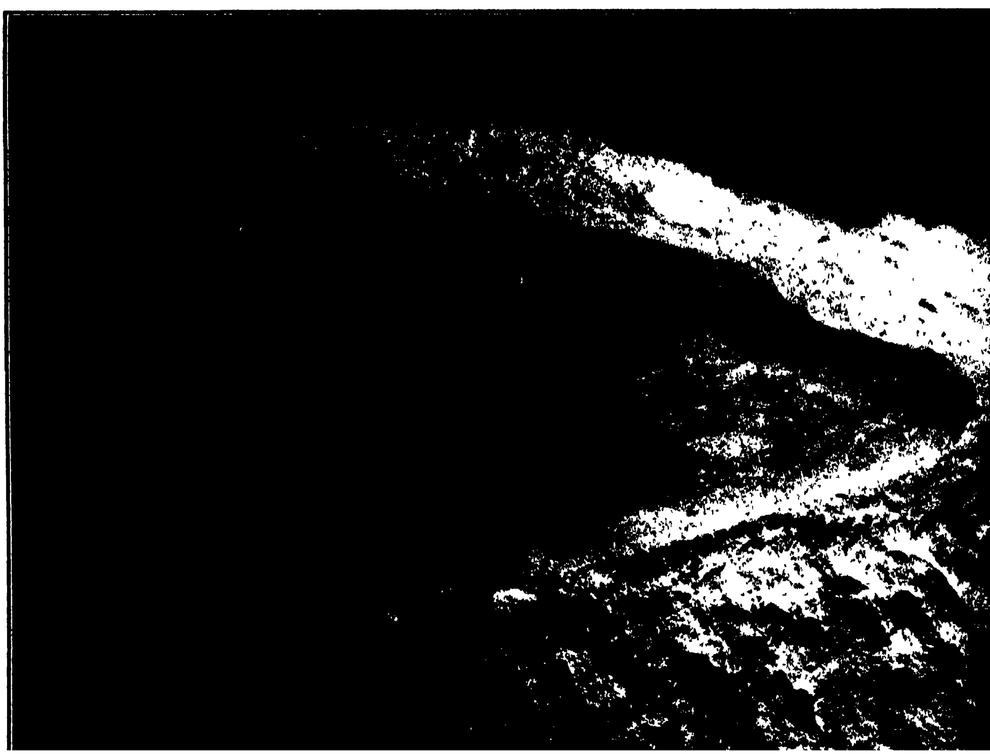
SECTION OF THE SURFACE WALLS WHERE EASTERN ENTRANCE JOINED THE MAIN TEMPLE.

THE EASTERN SLOPE OF THE TEMPLE, SHOWING CROMLICS SURROUNDING BASE.

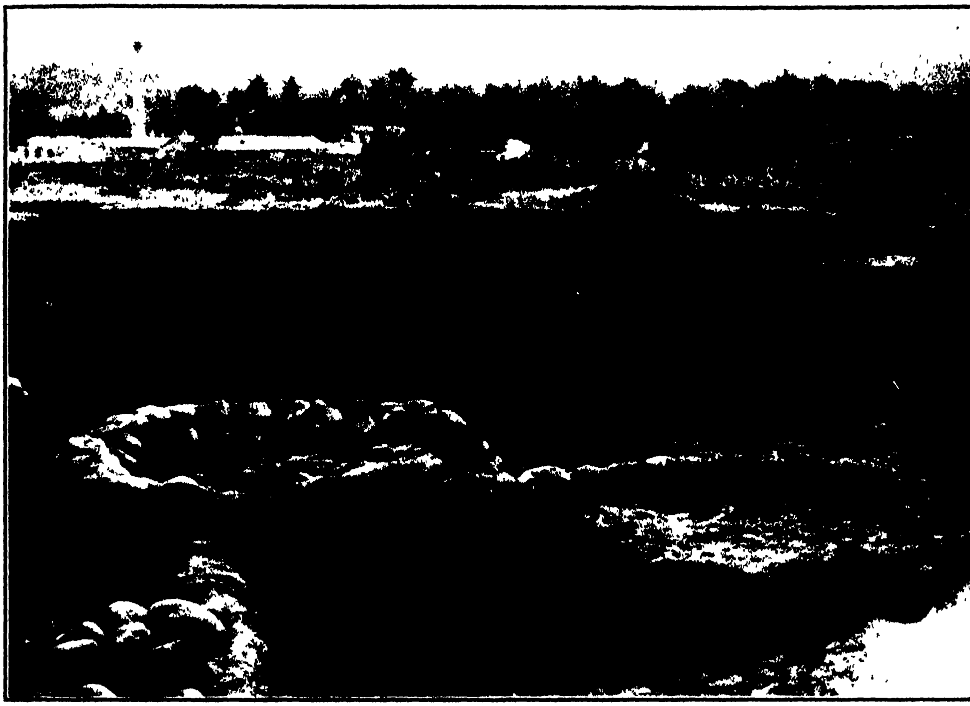
still gathered there to try and ward off the evil and win the favor of the spirits that bring life and health and peace. All was color, joy and abundance. The Earth Mother responded to their petitions and their industry and smiled upon them with her bounty. But one day the Fire God became restless and the mountains round about gleamed with livid red and the Wind Spirit wafted thick clouds over the sacred temple of the Sun, and Cuicuilco became covered with layer upon layer of pumice, sand and ashes. Dense rains followed that washed this light material down her slopes and packed it around her base. In places the water cut for itself channels along the surface of the walls and washed fine



THREE TYPES OF SURFACE WALLS ON THE EASTERN SIDE.



CLAY ALTAR BENEATH HORSESHOE ROCK ALTAR.



A HORSE-SHOE-SHAPED ALTAR LYING BENEATH THE DIRT COVERING OF THE TOP OF CUICUILCO.

sediment into the interior of the structure. That the structure must have been flooded for a time is evidenced by the fact that it is filled with fine water-washed sediment to an average depth of 6 feet.

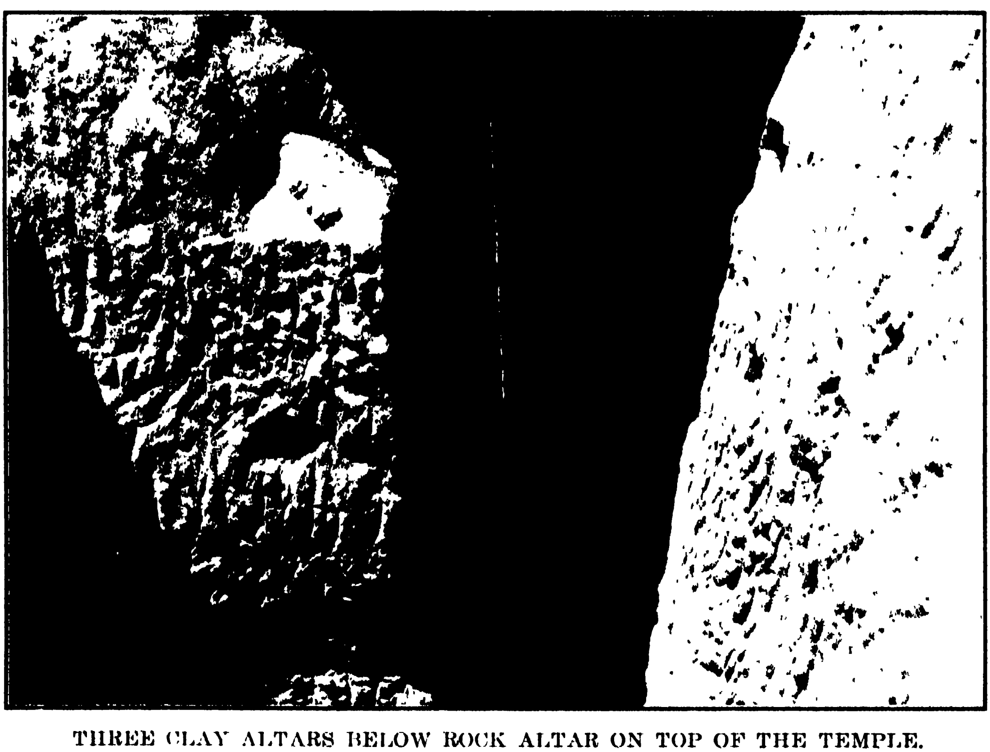
At some time during this period the waters subsided, the people were able to return to the locality, repair their temple and reestablish the worship of the gods. They did not undertake to clear away the volcanic material that covered the top but built a sustaining wall around the slope about 30 feet from the edge of the old platform and filled in the space behind, levelling it off for a dancing place in their ceremonials. In the center was raised another altar directly above those of their ancestors. Three other platforms were uncovered at different levels above this last one, showing that the surface was filled in from time to time and the sustaining wall carried higher and higher as the filling material demanded. There must have been a succession of volcanic eruptions that buried the altars and covered the surrounding platform. The first four of these altars were of clay painted red while the fifth was of water-worn boulders 22 feet long and 9 feet wide. The eastern half was 3½ feet high and shaped like a horseshoe. This altar rested upon a circular platform 68 feet in diameter made of large chunks of lava bedded in clay and sand. Four feet above this rock altar can be traced a clay floor upon which rests a foot of fine pumice covered with a thin stratum of black volcanic ash that must represent the surface level at the time of the eruption of Xitli and the flow of the "Pedregal" lava. Overlying this are eighteen inches of surface loam.

On this last and highest floor level there is no central altar, but slightly to

the southwest of the center rose a cone of lava rock and earth about 15 feet high. This must have been crowned by some sort of a wooden structure as old postholes were encountered in which had once stood quite large round timbers. This cone, with its wooden superstructure, must have taken the place of the central altar and must have been the center of the ceremonials celebrated on this spot by the last people who used the ancient temple.

These six platforms and their surrounding pavements superimposed at different levels through a depth of 18 feet demonstrate the long period of time through which men and women were accustomed to gather in this spot to appease the wrath of the gods and win their cooperation. And in the entire structure, even in the cone of rock surrounding the last pavement, no lava of the Pedregal period appears. The builders of this temple through its various stages of enlargement and repair all lived, built, worshipped and passed away before Xitli sent out its baptism of fire, followed by the great flood of seething, blistering lava that crept down the mountain slopes and out over the plain, burning everything to a crisp in its wake and surrounding the ancient temple of Cuicuilco, driving its worshippers before its scorching breath to seek safety in some part of the valley not cursed by the Fire God.

Above the base had accumulated from 15 to 19 feet of clay, sand and rocks before the lava flow occurred. This material was quite well stratified, consisting at the base of a layer of varying depths of fine sand and clay packed so hard that it could be removed only with a good sharp pick and plenty of muscle. Above this lay a stratum of rock that had tumbled down from the walls above with which was mingled soil containing organic material. In this stratum were

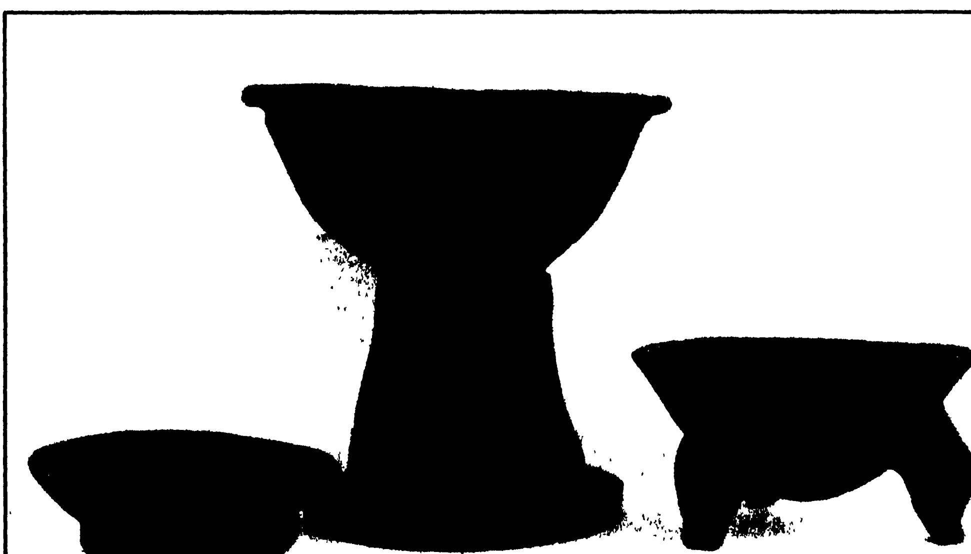


THREE CLAY ALTARS BELOW ROCK ALTAR ON TOP OF THE TEMPLE.

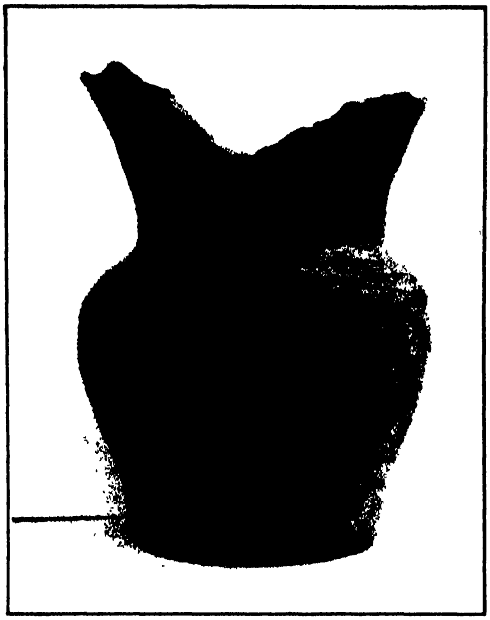
found broken pottery, clay figurines and crude stone inplements. Above this is spread from 3 to 4 feet of fine yellow pumice, clay and sand similar to the covering found on top. In this are found no human artifacts. An occasional chip of obsidian is the only thing that indicates the possible presence of man; but these even could be flakes broken off by nature. Overlying this is another stratum of rock and organic soil, which contains human artifacts in the shape of pottery, clay figurines and stone implements. These in time were covered with a stratum of yellow clay and sand 2 to 4 feet thick, of quite even consistency. Resting upon this is a layer of organic soil and rock that plainly was a surface level occupied by man for a long time. This is covered with a few inches of black volcanic sand, ashes and carbonized material, over which spreads the lava of the Pedregal. The lava sheet that crept in around the structure is from 5 to 20 feet in thickness and plainly poured over the plain in three successive flows. But fortunately the temple was so completely covered with earth and rock that the lava nowhere came in contact with the walls of the structure. About Cuicuilco above the edge of the lava and the carbonized stratum of that period lie on an average 2½ feet of surface soil in which are found some fragments of Toltec and Aztec pottery, and numerous obsidian blades struck from a core in long curving flakes.

Human remains were encountered in all these four levels, but all badly decayed and badly crushed. A few have been sufficiently preserved to judge their general physical characteristics. Their crania are dolicocephalic, of natural development with a strong underjaw, rather marked prognathism, strong supraorbital ridges, a low receding forehead and a high medial crest. They are quite similar to the crania of the cave people and the earliest pueblo people of Arizona.

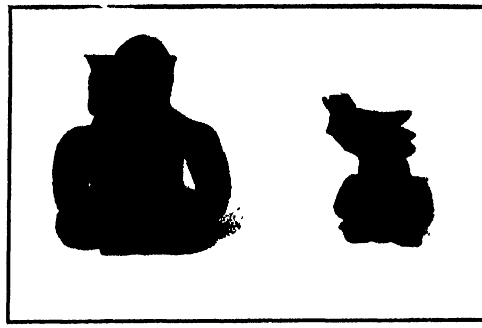
The pottery of the lowest stratum is monochrome, either in natural reddish brown color of the clay or painted a brilliant red. All are well polished and well



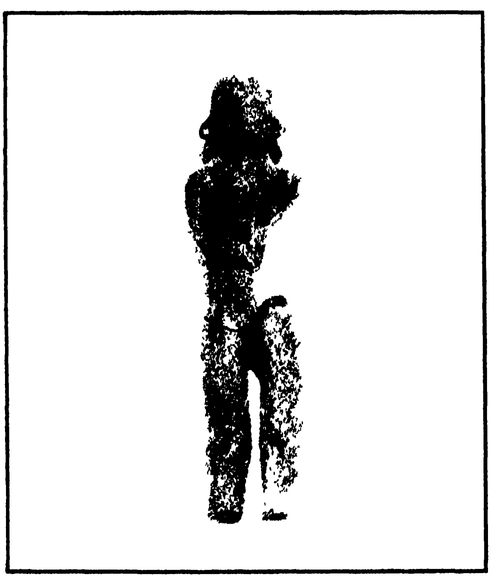
POTTERY FROM BENEATH THE LAVA ON THE SLOPE OF CUICUILCO. JUST BELOW LAVA.



POTTERY FROM CUICUILCO. JUST BELOW THE LAVA.

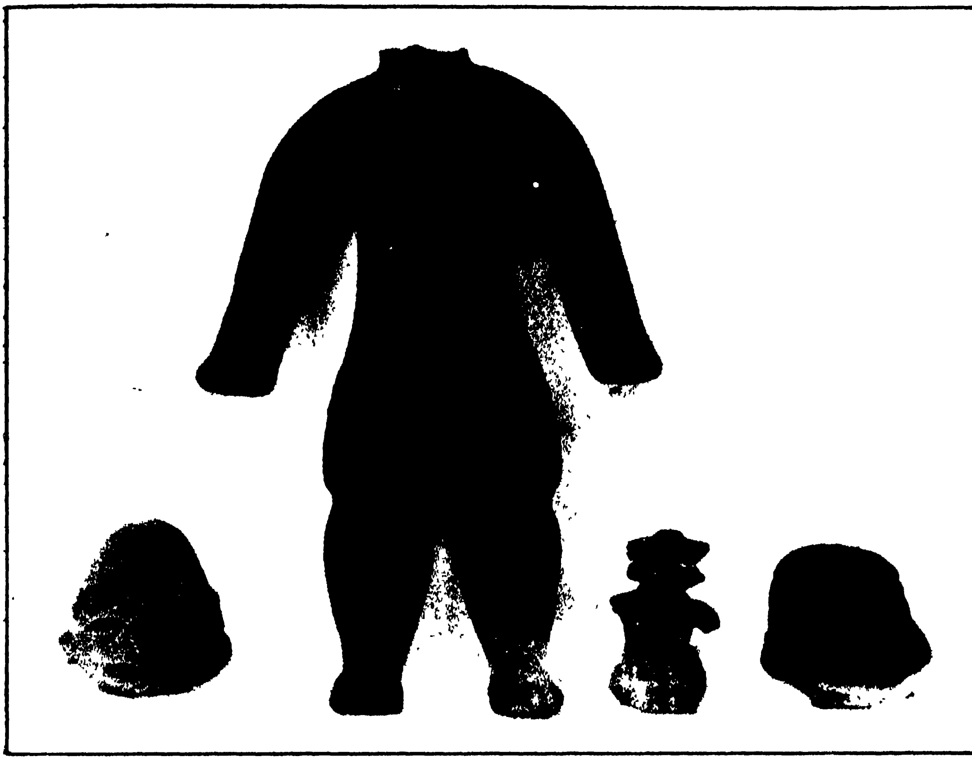


IDOLS FROM CUICUILCO. CLAY FIGURINES WITH RECEPTACLES FOR INCENSE. FOUND AT EDGE OF LAVA.



FIGURINE TYPE FOUND NEAR BASE OF TEMPLE, 15 TO 19 FEET BELOW.

FIGURINE TYPE FOUND JUST BELOW THE LAVA.



FIGURINE TYPES FOUND 6 TO 8 FEET BELOW THE LAVA.

shaped. The figurines are small, stiff and erect in position, with a receding forehead and a high crested head. The prominent nose and the receding forehead suggest the Mayan type of later date. The hair is represented as long and arranged in various elaborate braids and rolls and falls over the shoulders and down the back.

In the second stratum at an average of about 6 feet above the base similar pottery is encountered but of more varied form and a little attempt at decoration is seen in the grooved necks of some ollas. The brilliant red has nearly disappeared and there is a greater preponderance of reddish yellow and dark brown. The figures are much better shaped and finished. The features are much better formed but are still conventional and the headdress consists of numerous fillets intertwined with the hair. A considerable variety of position is found and the seated figures with crossed legs were introduced.

The stratum occupying the first two feet below the lava contains many human artifacts and remains. The population occupying the surrounding plain must have been numerous, but their culture was crude. The pottery was mostly thick black and reddish brown in cazuelas, shallow bowls and cups. The surface is fairly well smoothed but is irregular and unpolished. Some crude pieces have a decoration consisting of a band or rope of clay overlaid upon the surface and arranged in a wave line or indented with the thumb. The figurines are flat and squatty with crudely molded features and a turban-like headdress. The eyes and mouth are made by sticking strips of clay on the face, and the former are often set obliquely. Some of the figures

have the seated pose similar to the characteristic pose of Buddha. This culture could not have been an outgrowth from either of those already mentioned as the earliest. It was the attainment of a cruder people who after the second great covering of Cuicuilco came into the region and took possession of the land. They very likely were a more barbaric people from some remote section of the wooded mountains who moved down into the plain after the earth became quiet and sought to maintain themselves in the more fertile plains.

Thus three quite distinct periods of archaic culture are manifest beneath the lava of the Pedregal in the the Valley of Mexico. The first and the second periods show superior workmanship in pottery and figurines to that encountered in the third or latest. The first and earliest presents characteristics in pottery and figurines different from any artifacts hitherto encountered in the remains of the archaic age uncovered at San Angel and other places in Mexico.

If the lava flow occurred at least two thousand years ago as attested by three most eminent geologists, Tempest Anderson, of England, Karl Vittich, of Germany, and N. M. Darton, of the U. S. Geological Survey, then the geological and cultural stratification of the deposits lying between the base of Cuicuilco and the lava indicate the lapse of a much longer period of time between the building of the temple, Cuicuilco, and the eruption of Xitli and the formation of the Pedregal. Eight thousand years is a very conservative estimate of the time that has elapsed since the primitive people toiled up the slopes of Cuicuilco and reared a mighty temple to their gods.

RESTING BENEATH 20 FEET OF LAVA AND DEBRIS.

THE DUTY OF ASKING QUESTIONS AND THE PRIVILEGE OF DRAWING PICTURES

By Professor H. F. MOORE
UNIVERSITY OF ILLINOIS

WISHING to follow the best American traditions, the writer will begin this paper by telling a story. Following the most dignified traditions, the story is an old story. The writer thinks that it is a good story.

The small boy with the cherub face gazes up into his mother's eyes. "Mother," he says, "what does God look like?" "Hush, dear, you must not ask such irreverent questions." Follows a silence so prolonged that mother becomes anxious—a glance shows that the cherub is busy with pencil and paper. "What are you doing, dear?" "Drawing a picture of God." "But, dear child, no one knows what God looks like." "They will when I finish this picture."

Let us consider the above story from the viewpoint of the research worker in science, let us consider it under three headings: (1) The tendency of the small boy to ask questions, difficult questions, questions unsettling to many fond preconceptions; (2) the reaction of the mother towards such questions, a reaction in which every one of us has taken part many times—sometimes at the sending end, and sometimes at the receiving end; (3) the tendency of the small boy to create a concept which shall answer his own question—an attempt made with very inadequate preparation and with poorly developed technique.

Taking up the first division of our subject, the writer wishes to advance the thesis that in asking what God looked like the small boy was following a course of action which is eminently praiseworthy, always for investigators in "pure" science, nearly always for workers in "applied" science, and frequently for literary men, musicians and painters. It is, the writer holds, the bounden duty of the searcher to search, and to search with especial diligence in the places where he is vigorously assured that the object of search can not be found or where former search has been in vain.

For any one engaged in any kind of scientific research the constant attitude of questioning is so much a matter of course that it seems almost as strange to speak of the *duty* of asking questions as it would be to speak of the *duty* of eating. But to the devout soul who finds worship easier and more satisfactory than investigation the *duty of asking questions* is by no means clear. When we speak of there being no conflict between science and religion we must bear in mind that when considering his professional field of work, and during office hours, the effective research worker shows only the minutest traces of childlike faith in any revelation or authority. He questions the statements which the text-books call laws. He is not afraid to ask, "Are Newton's laws of motion really true, or must we regard them as good working approximations for terrestrial mechanics?" He squarely faces the query, "Is there a qualitative difference between the intellectual life of man and the intellectual life of other beings having animal life, or is the difference merely quantitative?" He does not shrink from or sidestep the question, "Is there any evidence of observable phenomena tending to prove the existence of individual life after physical

So the elastician draws a picture of the behavior of metals from the viewpoint of their minute changes of form under pushes, pulls, bending or twisting; the engineer draws a picture of the behavior of metals from the viewpoint of their resistance to being pulled in two, or crushed, or sheared off, and the metallurgist draws a picture from the viewpoint of the crystalline architecture of the metal, and the pictures are decidedly different. Yet each is a serviceable picture of some phase of the behavior of metals; none of the three pictures is a *complete* picture of the behavior of the metals, and none of them can be characterized as "untrue."

Will the reader step aside from the path a moment and in imagination take a view of four pictures of "patriotism" painted, respectively, by General Pershing, Jane Addams, Herbert Hoover and Calvin Coolidge?

To persons who have been accustomed to getting ideas of what scientists think from popular writings about scientists and scientific work the thesis that scientific theories are merely pictures must sound like nonsense. Do we not hear how Dr. Jones has "absolutely proved" the correctness of this theory and that Professor Brown has "completely demolished" that hypothesis? Are we not assured again and again that science rests on a basis of *proved* fact, proved by experiment? In the recent anthropoid carnival at Dayton, Tennessee, were we not told that unless he had a basis of *proved fact* the scientist must not cry aloud nor let his voice be heard in the streets, but must leave the classroom and the lecture platform to the less fettered preacher and lawyer.

As representative of the views of scientists themselves the writer wishes to present a translation of a paragraph in a little book, "L'Unité de la Science," by M. Leclerc du Sablon. The paragraph occurs in a chapter on the principle of causality, in which the author, who is professor of botany in the University of Toulouse, is discussing the basis for the principle which is fundamental to all other scientific theories and laws—the principle which states that there *are* causes and effects.

> The principle of causality, like other principles, is a concept of our mind, suggested by experience, but going beyond the data of experience. We conceive that the same causes bring about the same effects, although we have never seen two phenomena exactly alike. We believe in determinism in the realm of physical and biological phenomena, although there has been given only an approximate verification of that proposition for a limited number of cases. When we observe a happening whose cause escapes our observation we *prefer* to acknowledge our ignorance and our inability to discover the cause rather than to admit that there may be effects without causes and phenomena entirely independent of laws.

The assumption of cause and effect fits in well with nearly all the happenings we observe from day to day—at least with the happenings in the world of material things; the assumption enables us to think, and rather than passing time idly watching the clock of life we "prefer" an occasional attempt to "see the wheels go round."

Now if the very existence of cause and effect is an assumption which we accept because we "prefer" it to other assumptions, is it not reasonable enough to regard all postulates, hypotheses, theories and laws not as statements based on "proved fact" but as pictures which represent clearly and fairly accurately the happenings which experienced observers have witnessed? When a new picture is presented for our inspection we ask not is it "true" or "false" but "Is the new picture a better picture than the old pictures of the same thing?" "Is it more beautiful?" "Is it more accurate in its draftsmanship?" We do not expect the old pictures to be torn down at once from the walls of the scien-

tific picture galleries, but rather that for a while both the new and the old pictures shall hang on the walls until the scientist has decided which picture he prefers.

For something like two and a quarter centuries every student of mechanics had one and only one picture hung on the walls of his mental workshop; the picture of masses and accelerations painted by Isaac Newton in the "Principia." Then came questioners—Michelson and Morley and others, who began to ask if Newton's picture really did represent masses and accelerations or whether it was a vivid but inaccurate cartoon. Then came Einstein with another picture for the student of dynamics to hang on his workshop walls. But the Newton picture is not torn down. In fact, for engineers and most earthly mortals it is still the picture we look at. The masses and accelerations we have to work with do fit with the Newton picture very well indeed. The student of atomic behavior and the astronomer may have to hang the new picture on their walls, but the writer ventures to predict that it will be a long time before the Newtonian picture is torn down.

But before it is hastily concluded that we are to approve the attempt of our small boy to draw a picture of God let us consider one danger which is always present for the drawer of pictures. Folks do not worship *questions;* they are very apt to worship *pictures.* The giver of the ten commandments clearly recognized this danger and sternly forbade attempts to make pictures of God on the ground that one is very likely to fall down and worship the picture he has made.

Idolatry is by no means absent from the world of science. One of the commonest forms of scientific idolatry is formula worship. A scientist, either a pure scientist or an applied scientist, starts to develop a hypothesis. He finds it convenient to borrow a set of tools from his cousin the mathematician. Now there is no more fascinating employment than playing with mathematical tools—note I say playing with mathematical tools, which does not necessarily imply becoming a mathematician; and the beautiful regularity of the picture carved out by the mathematical tools makes the scientist forget what he was drawing a picture of and declare not that he has drawn a picture, but that he is telling the whole truth and nothing but the truth about his subject of research. Take, for example, the theory of elasticity, a beautiful picture, a most useful picture, a picture drawn by artists of marvelous technical skill. It does not tell the whole truth about the elasticity of actual materials because actual materials do not have the perfect homogeneity and the indefinite divisibility which are assumed for materials in the picture. For most cases the picture may be regarded as of sufficient accuracy for use, but it is not by any means inerrant, nor is it the complete expression of the truth about the elastic behavior of materials. Yet many an engineer worships unquestioningly the theory of elasticity.

The writer has chosen as an example of scientific idolatry terrestrial mechanics, a science which has been singularly free from passion and emotion in its development (in sharp contrast to celestial mechanics). If we consider the history of astronomy or biology we shall find that in those fields picture worship has roused storms of passion. How easy it is for a biologist to become a propagandist for the theory of evolution—as he interprets that theory—and how very easy indeed is it for an emotional Bible worshipper to become a propagandist against evolution—as he sees it. The marvel is that the great bulk of biologists and preachers have not become seriously entangled in the current tournament of slogans and mud slinging about evolution.

The writer's objection to idolatry are two in number: first idolatry leads to propaganda and undignified quarrels. The spirit of search and questioning makes a man humble, the spirit of idolatry makes a man cocksure and filled with a desire to impose his sureness on his neighbor. The writer does not like either propaganda or undignified quarrels—there is a fascination in a fight, but it is a devilish fascination. The second objection to scientific idolatry is more serious. Scientific idolatry shuts off questions and discourages or forbids the drawing of new pictures.

In view of the ease with which folks come to worship pictures, especially pictures which they themselves have drawn, the writer is not at all sure that our little boy was justified in trying to draw a picture of God. The drawing of pictures is not a duty, nor even an inherent right, but a privilege to be won. There is no intention of offering suggestions for the organization of a license board from which would-be scientific theorists might receive leave to carry on their trade. However, before a scientist should essay to draw pictures of his science—or at least before he essays to exhibit such pictures—he should have some training in draftsmanship, and he certainly should have training in observation so that he can distinguish the high lights and the deep shadows in the thing he is trying to draw. There is no more effective way of drawing a false picture or of making a misleading hypothesis than the insistence on equal emphasis for important and unimportant details. Frequently a flat characterless photograph is far less true as a picture than a sketchy cartoon.

On the ground of ability to evaluate emphasis and on the ground of drafting ability I fear we must withhold approval of the attempt of our small boy to draw a picture of God.

Now the writer wishes to maintain that the would-be drawer of scientific pictures should have the ability and the willingness to look at his world from more than one viewpoint. He recommends to all such the rereading of Saxe's satirical ditty on the six blind men of Hindustan who went to see the elephant, and who as the result of their several observations were firmly convinced that the elephant was like (1) a wall, (2) a snake, (3) a fan, (4) a rope, (5) a tree and (6) a spear; and how "these men of Hindustan disputed loud and long . . . though each was partly in the right and all were in the wrong." The painter of pictures will finally choose one viewpoint for his picture, but he does so only after he has recognized that there *are* other viewpoints and he looked at things from them. Moreover, he does not think of his selected viewpoint as "right" against the other "wrong" viewpoints. He thinks of it as better serving his purpose.

But let us listen to the objectors to the multi-viewpoint requirement. In that group we see the philosopher of mechanics, Ernst Mach, who already has spoken to us, and who speaks of

> That ideal of a *monistic* view of the world, which is alone compatible with the economy of a sound mind.

And he voices the feeling of many a trained scientific worker and of some disciples of idealism that the considering of many viewpoints leads to a hazy, lazy, vague mysticism and that the maker of scientific hypotheses should take only one viewpoint.

Is a monistic concept of the world possible at the present time? Can it be made a clear concept? Is it a desirable concept? On the first of these questions the writer would vote in the affirmative, but he would swing to the negative side on the second and third questions. In an attempt to justify his vote he asks you to look at two pictures hung on the

walls of the International Gallery of Hypotheses and Theories. One picture is labeled "determinism" and shows the world as a toy electric train running round a circular track in a Christmas toyshop window. The men and women in the train are little tin images, and acting in response to imposed accelerations they make certain determined movements. The motive power is entirely outside the picture, and the train goes round and round and round and round. The picture shows spectators (large tin images, says the painter) who seem to be talking vigorously, doubtless declaring that on the hundredth circuit the speed of the train is less than on the first and computing when the train will stop.

And this, says the painter of the determinism picture, is a picture of *us.* We are the little tin passengers, and we move and love and hate and eat and beget and joke only as imposed accelerations reach us, and then we act according to a fixed, imposed plan.

But the painter of the determinism picture has not given an altogether convincing picture. Our attention drifts toward the folks looking in through the toyshop window, and though our determinist painter says they are merely larger images, yet it seems a very evident fact that each one of them can *choose* whether to stand looking in at the window or to go home to supper and that probably some of them can choose to go into the store and buy the train. The painter himself has come up as we are looking at his picture and he says that choice is all illusion, and makes a rapid pencil sketch to show how really the apparent choice is an effect from a predetermined arrangement of atoms into foreordained patterns. There are millions of billions of atoms involved; he indicates these with some heavy shading. We can not say his picture is false, but it certainly is complicated and foggy, it arouses in some of our minds about the same degree of enthusiasm as did the famous futurist picture of the nude descending a stairway, in which it was very difficult to tell the nude from the stairway. We are not convinced and move over to view the other picture.

The second picture is labeled "Purposiveness," and the painter, a keen, confident man, immaculately dressed, stands beside it. This picture also purports to be a complete picture of the world. It shows a tall stern-faced man pointing with unshaking index finger towards a point due west where a very steep mountain towers into the air with a remarkably snaky path winding up its side along which a few pilgrims are toiling. There is a wild torrent which crosses the path at frequent intervals. It is a very "live" picture. One can almost hear the crisp slogans from the lips of the stern-faced man, "Go forth and conquer," "He who will, can." "Others have achieved, why not you?" and we begin to feel that here is the real monistic concept of the world until a humble individual with a slide rule asks for an estimate of the coefficient of friction between sole leather and the surface of the winding pathway, and about the nature of the bed of the raging torrent which must be crossed many times before reaching the summit. The painter replies in a ringing baritone voice, "The human will can overcome all obstacles," but the man with the slide rule shoves it in and out like a small trombone and shakes his head.

No, the second picture is not convincing, either. Any one could climb the hill for a greater or less distance, but there are loose stones on the paths, uncertain footing in the stream, and the possibility of nightfall ere the summit is reached. We know of no one who ever climbed quite to the top of his particular hill, and we turn away from this picture.

Chancing to step back a bit and taking one glance in the direction of the two

pictures we suddenly become aware that they go very well together. The high lights and deep shadows of the "purposiveness" picture make a pleasant contrast with the flat tones and clear-cut drawing of the "determinist" picture, and we spend the rest of our time in the picture gallery gazing at both pictures. To be sure, certain of the group round the "determinist" picture glance our way and make scornful remarks about "mystics," tapping the forehead significantly. Then some of the group round the "purposiveness" picture urge us to cease from halting between two opinions and ally ourselves with the strong, purposive folk ("red-blooded he-men," one enthusiast calls them). But still to us the middle viewpoint is best and pleasantest. We "prefer" it. I wonder whether to-morrow or next week yet another picture will hang in the gallery, and whether it will be a more nearly complete picture.

On the ground of ability to see what he is depicting from several viewpoints we can not justify our small boy in his attempt to draw a picture of God. Children are notoriously monistic in their view of the world, which they take at any given time, and if the boy's mother destroyed his half-drawn picture we can not blame her as we did for suppressing his question. Yet I like to picture the small boy say fifty years later. He is still drawing pictures, and now his mother no longer suppresses them. As he works away at his easel a friend enters the room and asks, "What are you drawing now?" and the grown-up boy, who has seen life from many viewpoints and who has learned the importance of high lights and shadows, answers "I am drawing a picture which I hope will make folks think about God."

RACE AND CULTURE

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SOCIAL development is intimately related to biological species. The fowl of the air are almost the only architectural nest-builders. Not only so, each species of birds has special methods of nest-building which no other species duplicates. The dams constructed by beavers are peculiar to them. Some animals are by nature social, while others live an isolated and irresponsible life. Some are amenable to civilizing influences and can be domesticated, while others, such as the tiger, refuse to enter man's social circle, and reject the social contract. The timid are timid by nature, the ferocious are born ferocious and ferocious remain.

The qualities peculiar to the species are inherited. The nest-builder owes its abilities to its ancestors. The humming bird falls heir to one type of nest-building art, the swallow to another; beavers are indebted to beavers for the ability to construct the peculiar type of dam of which they are capable.

Mankind constitutes a species apart from the rest of the animal kingdom and has social attributes not shared by the other animals. But in addition to being a species apart from the rest of the animal kingdom, man exhibits within his species such marked differences in physical characteristics that varieties or races of mankind are recognized and by some are reckoned as of primary importance in social life.

SPECIFIC RACE TRAITS

The differences in mental and in social make-up exhibited by the various races are accepted as specific race traits, qualities innate in a given race, not shared or shared only partially by other races. Assertion of race superiority and race inferiority is equivalent to a declaration of limited possibilities of advance due to the factor of race. There are considerable differences between one race and another, differences as old as history, and the recognition of the existence of these differences is almost as old as historical documents. The Egyptian, the Persian, the Assyrian, each had specific qualities better known than admired by contemporaries. The Greeks believed they constituted a class far above the *barbaroi* of the non-Greek world. In his own eyes, the Roman, by virtue of birth, was superior to other peoples. The Latin considers his race superior to that of the Teuton, and both agree on their respective superiority over the Slav. Their case is the stronger because race differences not only exist but persist.

According to some writers, social development demands a certain kind of racial substratum. Thanks to this substratum the stream of race differences flows on, each within the confining banks imposed by race potentiality. The findings of ethnology have called attention to the fact that culture differences may be innate in race. Differences which exist and have existed for many centuries between Mongoloid, Caucasoid, and Negroid, suggest that in race there is something more than mere diverging streams of historical influences. The foundation for these innate race characteristics sometimes has been assigned to morphological differences, especially to differences indicating that in physical make-up the lower peoples are more closely akin to anthropoid apes than are Europeans. In the negro one finds the long head, long heel, long forearm. Size of brain in proportion to size of body is less in Negro than in European. These

characteristics, however, justify no inference as to social or mental qualities. Physical resemblance to anthropoid apes establishes nothing more than physical resemblance. One can not infer that the type nearest the apes in physical characteristics is also nearest them in social and in mental characteristics. The structure of the European male, for example, is nearer the type of ape than is that of the female, though a marked leaning toward the ape in mental life of males as contrasted with females would be ardently denied by many members of the stronger sex. The proportion of size of brain to size of body is much less in the adult than in the infant, yet most philosophers would deny that in this case intelligence decreases as body outruns brain. The applications of similar logic to problems of race is obvious.

Attempts have been made to discover race differences in innate psychic constitution. Some races are represented as having strong emotional tendencies, others as being naturally phlegmatic, with corresponding differences in culture achievement. The experimental psychologist has taken his laboratory to primitive peoples or has brought representatives of primitive peoples to his laboratory, in order to study physiological and elementary psychological reactions. In sense discriminations, acuteness of hearing, touch, sight, no differences were detected which might not be credited to differences in previous training, experience and the almost controlling factor of interest.

The natives of the Torres Straits, for example, discriminate objects in a dim light better than do Europeans; but they are accustomed to finding their way about in no other light than that of a campfire, a torch, or the stars and moon. The European, accustomed to artificial illumination, has little practice in a game at which the savage has much experience.

It is not clear, therefore, that the results of these psychological experiments reflect differences attributable to race. Possibly they show merely differences in education and in interest. If such be the case, the test is a test of culture rather than a test of race. Commenting on his psychological observations among the Urales and Sholagas of the Indian jungle, Dr. W. H. R. Rivers, who has made more psychological tests among savages than has any one else, says:

> These people were hardly ideal subjects for psychological experiments.
>
> They came to us in a state of abject fear at the prospect of our examination, and in some cases continued so terrified throughout that their observations were of little value. In most cases, however, they soon found that we were comparatively harmless, and settled down to their observations satisfactorily, to become again much alarmed when they thought over the meaning and probable consequences of the examination.

This state of alarm and of apprehension, of divided interest and attention, in varying degree is characteristic of all primitive peoples with whom the psychologist deals. These disturbing elements must greatly vary the results and in so far vitiate the value of the findings. Until the results of the experiments are weighted they possess little value as tests of the psychological capacities of primitive peoples.

The importance of "consciousness of the task" as a factor in determining performance has been well stated by a contemporary psychologist.

> There is, for example [says Bartlett], all that may be involved in the understanding of instructions given, in the subject's own conclusions with regard to the purpose of the experiment, and in the affective accompaniment of his responses. Beyond these intellectual and affective characters, however, consciousness of the task appears in all cases to involve what must be described as an active prompting, contributed by the subject himself, in the direction of this or that type of response. . . . Any one who has had any experience whatever in the setting and marking of mental tests will at once recognize how great a difference this active cooperation of the subject may make.[1]

[1] F. C. Bartlett, "Psychology and Primitive Culture," 270–1. New York, 1923.

In the experiments of Rivers above referred to the highest rating in the vision test was scored by a Sholaga serving under the Forestry Department as bungalow watcher. He discerned correctly the position of the letter E at a distance of eighteen meters. Rivers deemed him "distinctly superior to the rest in general intelligence, though it may only have been that he had had more intercourse with the outside world, and was, in consequence, less timid and reserved." May it not have been due in part also to his experience and training as a bungalow watcher, a vocation which gave him in the tests a fitness which the others could not claim?

INTELLIGENCE TESTS

Much has been made of the fact that the intelligence tests conducted in the United States army camps during the World War show a rating of negroes at a distinctly lower level than that of the whites. We give below the rating of intelligence percentages of inferior, average and superior:

Camp	(W = White; N = Negro)	No. of Cases	Percentage Inferior	Percentage Average	Percentage Superior
Lewis	W	834	8.4	72.9	18.7
	N	118	23.6	66.9	9.4
Devens	W	8,247	20.1	69.2	16.7
	N	114	32.4	65.7	1.8
Upton	W	7,876	22.1	66.6	11.3
	N	326	44.1	53.7	2.1
Dodge	W	4,575	18.3	80.6	11.1
	N	831	50.5	47.3	2.2
Custer	W	4,933	20.6	66.9	12.5
	N	819	58.3	38.6	3.1
Travis	W	6,514	34.4	56.1	9.5
	N	1,375	70.2	29.2	0.6
Grant	W	7,671	18.2	69.6	12.2
	N	1,129	76.3	22.8	0.9
Taylor	W	7,363	22.6	62.9	14.5
	N	2,416	80.3	19.0	0.8
Wadsworth	W	8,243	27.0	61.2	11.8
	N	1,634	92.8	7.0	0.1
All Camps	W	93,973	24.1	63.9	12.1
	N	18,891	78.7	20.6	0.7

If we take the total for all camps we find the lower intelligence more than three times as frequent in negroes as in whites, the higher intelligence about one eleventh as frequent, and the average intelligence less than one third as frequent. These differences, in varying degree, hold for each camp as well as for the total of all camps, the negroes invariably showing a higher proportion of cases of inferior intelligence, fewer of average intelligence and markedly less of superior intelligence. The ratios differ for both whites and negroes from camp to camp and differ more in the case of negroes than in the case of whites. In the case of negroes the highest ratio of superior and the lowest of inferior occurs in Camp Lewis, a camp of the northwest, the next lowest ratio of inferior being found in Camp Devens, a camp of the northeast, while highest ratio of inferior rating and the lowest of superior is in one of the southern camps, Camp Wadsworth The fluctuation from camp to camp in the rating of negroes suggests that the rating of the negro depends largely upon the state of origin. A tabulation of results according to state of origin of the negroes shows that the surmise is well founded. Among the states of nativity of negroes for which data are given for more than one hundred cases the greatest frequency of lowest rating occurs in South Carolina (77.7 per cent.), Alabama (67.6 per cent.), and Florida (68.2 per cent.); the highest percentage of average rating, known as "C," being found in Indiana (20 per cent.), Illinois (19 per cent.), and Kansas (21.4 per cent.). Geographical variations in rating are not peculiar to negroes but hold for whites as well, and "suggest that there probably are more or less marked differences in the levels of intelligence in different parts of the country"—a surmise which no one would challenge. In a word, the fluctuation in negro-rating suggests that the difference between negroes and

whites is to be credited to social heritage rather than to race.

The tests are standardized on the basis of Anglo-Saxon experience and education and show differences in social experience and tradition of which race is but a chance carrier. Devise tests which suit the intelligence, interest and training of the native Zulu and he will do better at them than will the average white. The relative standing depends considerably upon who devises the tests and upon the criteria imposed. Tests made, previously to the army tests, upon white and negro children show that the comparative rating of negro children varies with the social classes chosen for comparison. Attempts to select white and negro children of the same educational standing, as was done in tests made in the south, and in tests made in Philadelphia, where, at least in the latter case, the economic and home surroundings were taken into consideration, are in the right direction. But it is impossible to select groups of whites and groups of negroes of the same home environment. The traditions, aims, ambitions, hopes which pervade one group are different from those which pervade the other and are favorable to the whites. The comparison is fruitful only when we select those from the same environment, with the same training, experience and incentive.

Neither does the greater prevalence of feeblemindedness among negroes show that this is attributable to race. Is feeblemindedness more prevalent among the negroes in Africa than among those in the United States, or has this trait grown apace with contact with American civilization? When the psychologist answers that question we will have grounds for deductions about traits attributable to race. Not until then can we allege that the greater prevalence of feeblemindedness among the negroes of the United States is evidence of inferiority due to race.

As regards the interpretation of the mental tests applied to members of racial groups, it is assumed by some psychologists that the races should be rated according to the standing assigned individuals by the tests. This is putting the cart before the horse. The tests are justified or condemned according as they harmonize with otherwise demonstrated race intelligence. A test of the intelligence of individual members of a racial group does not give the intelligence rating of the race. The psychologist would scarcely maintain that the tests would show a lower rating of modern Greeks than of ancient Greeks; yet the differences in accomplishment are monumental. Moreover, an addition of individual qualities does not give the qualities of the race, neither does an average of individual qualities give it.

Mind does not develop in a vacuum. It develops only in a world in which organism acts on environment and environment on organism. In developing it takes on something of the complexion of the environment, however it may adapt environment to mental life. Given a common environment we have a common basis for comparison. But not unless the environment be really and not merely speciously the same.

By the map it may be the same, but in the psychological life of the inhabitants it may be very different. Part of the environment consists of social contacts, home influences, interests and aspirations; these, whether originating in the individual or in the group, form part of the psychological environment. Moreover, only that part of the environment has influence which meets the mind of the individual, directly or indirectly. The tests show that race differences exist; but they do not show that the differences are attributable to race, if by race is meant biological make-up apart from social influences and the incentives inseparable from social environment.

The Races have not shared the Same Culture Environment

Part of the misunderstanding of the significance of race is due to acceptance of a false analogy between race and individual. It is assumed that a race, like an individual, has its youth, development and old age. The analogy is misleading. As far as we know the races are of the same age. It makes no difference whether we say they are all young or all old. Their possibilities are not exhausted while physical stamina and integrity are unimpaired.

Competition has shifted from physical qualities to social qualities. Not man's physical endowment nor his physical inheritance determine his place in the world to-day, but his social environment and his social inheritance. These are made for him to a much larger extent than they are made by him. Whether I shall have command of the English language depends much more upon when and where I am born and raised than upon my personal qualities, and this holds of the greater share of my accomplishments. When we individualize the races we see that they have not lived in the same sort of world, have not had the same opportunities. Their varied accomplishments can not be attributed solely to innate characteristics. There is no reason to believe that the innate characteristics of Anglo-Saxons to-day are different from their innate characteristics in the first century B. C.; but the difference in the social environment makes of the individual Anglo-Saxon today a creature far different from his ancestors of two millennia ago. He does not owe this change to any change in physical heritage, but to a change in social heritage. Only in so far as the respective races have shared a same social heritage do we have ground for making comparisons as to the culture significance of racial equipment.

Relative Independence of Culture and Race

That culture is only casually and not causally associated with race is suggested by the lack of correlation between specific physical qualities and culture. Race characteristics consist of a difference in shape or proportions of nose, of head, in kind and amount of pigmentation, in color and texture of hair, and so on. A peculiar ensemble of these marks off one race group from another.

If these traits in their ensemble have culture significance one would expect to find that some one of them alone has culture significance. But it has not been shown that within any given racial group, Caucasoid or Negroid, the intelligence of the individual varies with elevation of nose, breadth of nose, color of hair or of skin.

If there is no correlation within a given racial group, the presumption is—though it is only presumption—that, taken in their totality, these several qualities have no causal relation to intelligence—probably not more than collars to Christianity.

The relative independence of culture and biological type is shown in the wide variations of culture associated with a given biological type. In the aboriginal New World we have—some physical anthropologists would not accede—a fairly homogeneous racial type, perhaps as homogeneous as any racial type. There is, however, no corresponding homogeneity of culture. From the Eskimo to the Aztecs the changes in culture are as significant as from Eskimo to Africa, or from ancient Rome to modern Rome. Intervening areas support a multiform culture, variations in which appear to be in no wise causally related to fluctuation in biological type. Thus homogeneity of biological type goes with heterogeneity of culture; the specific biological type appears to be only a chance carrier of the specific culture. The causes of the

culture content are to be found in culture and in history, rather than in biology.

The converse is true: heterogeneous biological type is a carrier of homogeneous culture. One finds in Britain, France, Germany, the same racial subtypes, occurring with different frequency in different localities. But the fluctuation in frequency seems to have no relation to the ability of type to carry the national culture. The sections of France in which Nordic type predominates carry Gallic cultures as easily as do localities in which the Nordic type is less frequent. From a study of his physical type no one can infer the culture of the Britisher—neither his politics, his religion, his language, his economic philosophy, nor even whether he belongs to Britain, France or Germany. All over Western, Central, Eastern, Europe homogeneous culture is carried by heterogeneous type. Thus the psychological tests used to exploit race differences really show the independence of race and culture. The group which the psychologist calls Italian, Bohemian, English, Dutch, and so forth, is not a racial group but a culture, or perhaps merely a political group, in which the same race qualities appear as in the other groups, differing only in relative frequency. The psychological tests show that race differences cancel out, can be disregarded. The culture differences of the respective groups persist irrespective of the racial complexion. The Italian rates above or below the Frenchman, German, or Bohemian, irrespective of his racial make-up—the nationals' racial make-up being a matter with which the psychologist has not been concerned and has not even taken note of.

Permanent Race Traits have not been Shown

The test of the reality of race traits is their permanence. Otherwise we shall not know whether race is the product of social tradition or social tradition is the product of race characteristics.

It is doubtful whether any "race" characteristics known to us within the social realm can be considered permanent; and if they are not permanent, they are not race characteristics, that is, are not inherent in biological structure. If we take cross-sections of history at chosen intervals race differences appear, but these differences are not constant, neither do they inhere in certain races only, but pass from one to another.

The conservatism of the Chinese has several tens of centuries to serve as witnesses to the permanence of this trait. But we rank conservatism as innately Chinese only because China still continues in that temperament. To-morrow China may right-about-face (if she did not do so yesterday). Had Japan not stirred with new life, we should now be adding that country to the list of peoples in whom conservatism is a permanent quality. Although the vigor of the Anglo-Saxon and the languor of the Negro have many centuries to attest their abidingness, it would be unwarranted assumption to allege that interchange of social quality is as impossible as interchange of complexion. The Ethiopian may not be able to change his skin, but he has shown that he is capable of changing his social life, nor do we know the limit to his capabilities. Comparison of races is made at an arbitrary period of history, the results of the comparison depending upon the century chosen. The comparative rating which we give Celts, Latins, Greeks, Negroes, Anglo-Saxons, varies with the century chosen for making the comparison. Gobineau's endeavor to save the case for race, which he opposes to geographical environment as the decisive factor in social advance, can not rest on the supposition that the purity of the dominant races was destroyed by the infusion of new blood, with consequent degeneration. Even though we admit that such an infusion resulted in

the overthrow of the Hebrews, of the Egyptians, of the Romans, we have yet to explain why the Hebrews rose to eminence in the seventh and sixth centuries B. C., millennia after the Egyptians had acquired world power.

If race brought the Romans into power, why did Roman racial qualities assert themselves only in the centuries following the decline of Greece, and not earlier? British power did not reach its apex until long after large infiltrations of other blood into the veins of Britons. Gobineau, therefore, does not account for the rise and fall of races, nor for the differences in race achievement in different centuries.

He fails, moreover, to take into the reckoning the fact that the story of races is not yet closed. With regard to any given race we must inquire, not merely, What rôle has it played in history? but also, What qualities will it exhibit in the long run? Japan was regarded as inferior to China, being but a feeble borrower of Chinese culture. Now that Japan has liberally borrowed from Western Europe, China, when she attempts to get the stride of European civilization, may have occasion to look up to Japan as her superior. Or will China maintain her own civilization, and Japan again have cause to look up to China—a Japan ruined by that same civilization which made her a modern country?

For all we know, some accident of external influence may have given rise to the culture differences which some would assign to race as a cause. Anglo-Saxon civilization would not have become what it is save for the historical accident of contact with Greco-Roman culture; though had it not been Anglo-Saxon culture it would not have responded as it did to these civilizing influences. Though its opportunity made it, it made its opportunity by accepting it and profiting from it. The people themselves must decide whether, as a result of new external influences, they will take new trend.

Though there are many similarities in reaction, no two groups of peoples have decided in identical manner this matter of utilizing opportunity. Germans have responded to the stimulus in one way, Anglo-Saxons in another, French in still another way. Each according to its bent works out its salvation or refuses to strive for salvation.

Ultimately the determinants of social development lie within the group and its environment, however much the development may be deflected by time and circumstance.

Though we can ascertain what a race has done in the past—and its accomplishments differ with each century—who can say when the group or race, responding to new external influences, or self-impelled, will take new trend and violate our fondest anticipations? The Negro may be moving more slowly toward the goal and be lingering behind the Anglo-Saxon, but is it not possible that he is moving more surely toward it while Anglo-Saxon civilization may be headed in the wrong direction, be on a tangent, and sure to miss the goal though certain to pass close to it? Each race can change the trend of its development. Each has a measure of self-determination which permits it to create or to destroy. It has the power of choice; and choice is elimination of the old as well as selection of the new. As the fulness of life falls within its purview so does the poverty of life and even suicide. The germs of greatness or ruin lie within all races, and we do not know the limits to their respective potentialities. Race qualities can not be finally determined until the race has run its course and then only in so far as the opportunities of the respective races have been equal, only in so far as the human experiment has been carried on under same or similar conditions by all races. In this respect races are comparable with individuals.

Since nature has not provided and laboratory and history does not record any conclusive experiments as to the

capacities of the races, positive evidence of race inequality is lacking. It is not race which handicaps individual and group or gives them impetus, but the social environment of individual or of group.

Other biological forces impinge upon the individual, but race is no handicap. Social, traditional, educative factors handicap or spur on the individual, not the biological factor of the race characteristics which happen to be associated with these social forces. If biological forces determine social development it is through some other medium than that of race.

Origin of the Interest in Race Superiority and Inferiority

The factors responsible for race are morphological or physiological, hence not subject to fluctuations owing to social currents or social interpretation. Yet considerable social importance attaches to race. Conviction of race superiority is largely the creation of peoples self-conscious in the presence of other races or cultures. The Hebrews attached little importance to race, since for them there were but two important divisions of mankind, the Chosen People and the Gentiles. The earlier Greeks made a similar dichotomy, using language rather than religion as the severing line. European thought displays no interest in race until the time of Camper, who noticed that the Ethiopians represented by Italian painters were remarkably Italian in feature, being in fact merely the Italian type painted black. Then came the distinctions of Linnaeus based on color, followed by those of Blumenbach and those of Retzius with emphasis on head-form. The classifications are from a chosen point of view designed to serve a specific purpose. This, perhaps, must be the case, but the purposes have little in common. The Hebrews are interested in religious differences, the Greeks in language and culture differences, Camper is looking for the proper anatomical or morphological make-up. The earlier physical anthropologists of the nineteenth century are looking for measurable proportions which mark off one people from another and will serve for archeology as well as for contemporary ethnology. After 1870 the race question is subservient to nationality. Broca, the veteran French anthropologist, sees the Germans as largely Slavic in composition. Virchow, the veteran German anthropologist, must needs controvert this by way of a mass of testimony to the contrary. Both are making offerings at the altar of nationalism.

With the progress of Darwinism during the past half century the compelling motive has been the subordination of race problems to the evolution hypothesis and the arrangement of races in a hierarchy.

Hence the feeling that the races can not be of equal capacity, since their accomplishments are so diverse. There must be higher, lower and intermediate. European peoples, being in the ascendancy, assume their physical type the supreme one, other types representing degeneration or primitiveness to the degree that they depart from the Caucasian type, though, as a matter of fact, the European type probably shows more "degeneration" than does any other.

If one grants the truth of the assumption of European superiority much can be adduced in support of it; but if one refuses to start with such an assumption it is exceedingly difficult to show the innate superiority or inferiority of a given race. It is not the correlations of race with intelligence quotient which has elicited the inference of race inferiority or superiority, but the inference has elicited the correlations. Had interest centered in the correlations they would not have stopped with race, and certainly would not have stopped until race type had been distinguished from nationality. If we read history and ethnology

aright, to assign a preeminent value to race is to confuse form with function, to assess a thing according to appearance rather than according to performance.

Summary

To sum up our findings regarding race: Potential function is as important as actual accomplishment and can not be left out of the reckoning.

Though races differ in accomplishment this difference is not constant through the centuries. It fluctuates as the culture life of neighbors changes, and independently of changes in the physical type of the group in question. If we view human life from the larger perspectives of time and place there is no reason to conclude that the potential functional or potential accomplishment of one physical type is above or below that of another. To conclude that races have different psychic potentialities one must rule out historic opportunity. This we can do only to a limited extent, if at all. So far as we can do so, the evidence is in favor of the thesis that race potentialities are not inherently different. Least of all can tests of individuals be taken as equivalent to tests of the qualities of the race to which those individuals belong. The physical differentiae of race are, for the most part, like beauty, only skin deep. Remove the epidermis and in most cases it becomes extremely difficult to distinguish races by any physical criteria.

So it is with psychic and social differences. Relieve people of accumulated historic, social and psychic influences, and the races stand out as essentially alike in potentiality.

The evidence of experimental psychology is largely negative. The differences between races shown by laboratory tests are small, and when we rule out interest and previous training and experience we are not sure that any differences inherent in race exist. The sense discrimination of the savage is practically that of the civilized man, that of the Negro does not differ from that of the Caucasian, that of the Oriental is like that of the European. No intelligence tests have been devised which bring within the same realm for comparison on an equitable basis the civilized man and the savage. Tests revised on the basis of those designed for use with school children of the lower grades show differences among European nationalities. But these national differences have not been correlated with physical differences.

The psychologist who has conducted the tests has not ascertained whether the individuals from different national groups are of different race (or of different racial sub-group), though in all probability many of the South Europeans tested are of different sub-race than the North Europeans tested. Chinese and Japanese rank high in intelligence tests. Negroes rank below whites, but how much below them depends upon the section of country in which they live, both absolute rating and relative rating being higher in those sections of the country in which the social opportunities of negroes more closely approximate those of whites.

By the test of behavioristic psychology what a race is is equivalent to what it does and can do; race qualities can not be inferred from the qualities of the individuals who compose the race, for the character of the group seldom is either the average or the sum of the characters of the individuals who compose it. Only when we test races living under like conditions do we have comparable data. Since the accomplishments of the respective races fluctuate considerably through the centuries, we have no reason to believe that one race differs from another in innate psychic equipment.

THE INFLUENCE OF THE WEATHER ON HUMAN CONDUCT

By Dr. EDWIN G. DEXTER
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Some years ago in the course of a discussion of school discipline with a group of teachers, one of them asked me why it was that during some kinds of weather the children "cut up" so.

That I thought was an easy one and blandly proceeded to pass on to something of real importance after having mentioned rainy day, lack of exercise, windows shut, etc., etc., with the air of one who feels that he has been unnecessarily interrupted. But it wouldn't do at all. They set upon me in a body. There was something in it, whether I believed it or not. Some days everybody was on edge and it was the weather, but I hadn't hit the nail on the head at all. I had distinctly lost caste in that community for not being up on my subject.

But I decided to get up on it, if there were any possible way and save myself humiliation in the future. As a result, the question of weather influences has been a kind of knitting work with me ever since; not climate—but weather, pure and simple: those day-to-day fluctuations in meteorological conditions which we all know so well. It is true that if any one of them becomes chronic —as heat or cold—it constitutes climate; but that was not what interested me. Whole libraries had been written on climatic effects, but who had ever said anything about those of the weather?

After a lot of browsing around, I found out. Some of the most eminent authors of all time had written on the subject: Shakespeare and Southey and Walt Whitman and Thoreau and Wordsworth and Byron and Tennyson and Dickens and Victor Hugo have touched upon the influence of the weather on human conduct, not to mention many other lesser lights.

If such men as these had made record of the thing, I was all the more willing to take my hat off to a bunch of schoolmarms in a remote county in Colorado, for that is where they had made their observation on the hopefuls of the nation.

But, you say: "When did Shakespeare and the rest of the authors you have listed ever mention such a thing? And what did they say about it?"

Shakespeare hinges the entire plot of Romeo and Juliet on the effects of a hot day. In the second act of that play he puts these words into Benvolio's mouth:

> I pray thee, good Mercutio, let's retire:
> The day is hot, the Capulets abroad,
> And if we meet, we shall not 'scape a brawl,
> For now, these hot days, is the mad blood stirring.

And again in Henry IV:

> But look you pray, all you that kiss my lady peace at home, that our armies meet not on a hot day.

Southey says:

> I miss the sun in heaven, having been upon a short allowance of sunbeams for the last ten days; and if the nervous fluid be the galvanic fluid, and the galvanic fluid the electric fluid, and the electric fluid condensed light, zounds! what an effect must these vile, dark, rainy clouds have upon a poor, nervous fellow like me, whose brain has been in a state of high illumination for the last fifteen months.

Byron confesses:

> I am always more religious on a sunshiny day, as if there were some association between

our internal approach to greater light and purity, and the kindler of this dark lantern of our external existence.

But, without more citations, E. O. Kirke, writing in the *Atlantic Monthly*, has summed the thing up as follows:

With Wordsworth and Tennyson began what might be called the weather cult: that is, the entire impenetration of the theme and the motive with the moods of the atmosphere. Dickens was perhaps the first of the modern writers to press fog and rain into his action as characters, powerful as those of flesh and blood; but this plan has been carried to its limit in certain books of Victor Hugo's, Pierre Loti's, Black's and Craddock's.

But these, you say, are men of genius. They are different. How about us humdrum denizens of an everyday world? Does it affect us that way?

According to the teachers I have mentioned, it evidently does. But how find out? We do not often jot down our impressions of such things. There must be a way. And there is.

It is true that we do not jot down our impressions, but if our conduct becomes sufficiently abnormal somebody else jots down his impression of us and makes it a matter of record in the police blotter; and if we study that carefully enough we can find out just how many of us were acting abnormally on a given day, or on all days for that matter. Then if we go to the trouble to determine what the weather was on a given day, or on all days, and make the proper tabulation, we can find out whether more people were acting abnormally under certain conditions of weather than under others; and, incidentally, determine whether Shakespeare and the rest were right in their deductions.

To illustrate.

The records of the U. S. Weather Bureau show, based upon observations of fifty years or more, that the average number of days each year at New York City characterized as clear is 107, while the average number on which there is some precipitation is 125; *i.e.*, 29 per cent. of the days at New York City are clear and 34 per cent. are more or less rainy. The rest are cloudy, but without precipitation.

That being the case, we might reasonably expect that of all peculiarities of human conduct for the inhabitants of New York City, 29 per cent. would have occurred on clear days and 34 per cent. on rainy or snowy days, *unless the character of the day* were an influencing factor, for this was the only condition of the environment that changed simultaneously for all. When one had a rainy day, all did, and when one had a clear day, it was a clear day for all. Such things as poor coffee at breakfast and dropped collar buttons and automobiles that refuse to start and the hundred and one petty annoyances that influence conduct are distributed pretty well through, and do not happen for everybody at the same time, as the rainy day does. The question then really is: Given the twenty thousand days covered by the Weather Bureau's data and the millions of people in New York City, can we say whether a man is any more likely to make a fuss about the poor coffee or to tip over the dresser in the hunt for his collar button or get profane about the automobile on a rainy day than on a clear day? In other words, is a lost collar button, plus a rainy day, worse than a lost collar button, plus a clear day, so far as its effect upon the conduct of the loser is concerned?

As to mere collar buttons, we can not tell, since they are not matters of record, but when it comes to exasperating circumstances of such a sort as to get one into the hands of the police the thing is quite possible though somewhat laborious. The police record will tell you how many were arrested on any given day in the last fifty years for any given offence, and the records of the Weather Bureau

will tell whether that day was clear, partly cloudy or cloudy and whether it rained or not. That leaves the question merely one of mathematics. As I have already said, it rains more or less on 34 per cent of the days at New York City. If for a long enough period of time to eliminate the accidental error common to all empirical problems, the total number arrested on rainy days exceeds 34 per cent. of the total number arrested on all the days of the period covered, both rainy and clear, then the rainy day has somehow done it, for there is nothing else that could. We have so many people in the great metropolis that the accidental may be completely ignored. Therefore, any mass variation in conduct, concomitant to variations in the meteorological conditions, are due to those conditions.

So far, so good; the weather is not merely rain and shine and heat and cold. There is a lot more to it. There is the wind that has set people on edge since the dawn of nerves; there are constant changes in relative humidity and barometric pressure, things which Shakespeare probably never heard of, but which after all may have a lot to do with it.

Those same records at the Weather Bureau that told us how many rainy days and how many clear days there are in a year also tell us the mean temperature, humidity, barometric pressure and wind velocity for every day for the last fifty years, the only trouble being that they do not publish them. You have to go there and dig them out. That is precisely what I did—not for the whole fifty years, but for twelve—long enough to form a valid expectancy curve—and when the job was over I had the mean temperature, humidity, barometric pressure and wind velocity, the character of the day and the precipitation for each of the 4,383 days of the twelve years.

This expectancy curve was based upon the percentile occurrence of each definite meteorological condition—for temperature each five degrees; for humidity each five per cent.; for barometric pressure each tenth of an inch; for movement of the wind each fifty miles for the twenty-four hours; for precipitation each tenth of an inch, and for character of the day the three divisions of clear, partly cloudy and cloudy.

You would agree with me, I presume, that since one seventh of all the days are Sundays, one seventh of everything that occurs will occur on Sunday unless there is something peculiar about Sunday to make them occur otherwise.

All right. If one seventh of all the days have a mean temperature between 60 and 65 degrees Fahrenheit, one seventh of everything that occurs should occur on days when the temperature is between 60 and 65 degrees Fahrenheit, unless there is something peculiar to that temperature which makes them occur otherwise. If that be true for the temperature group 60 to 65 degrees, it is true for every other temperature group, and for every other one of the fifty or more meteorological groups arbitrarily chosen. In other words, the percentage of occurrence of a meterological condition gives the percentage of expectancy for any peculiarity of human conduct under that meteorological condition.

So much for expectancy. How about occurrence?

This took me wherever a record of human conduct for New York City was kept in the form of a daily tabulation, for it was necessary to know the exact date of the abnormal act in order to determine the meteorological condition under which it occurred.

For the twelve years covered by the study, the police records for the city of New York showed 39,761 arrests for assault and battery; that is, for that number (3,134 of whom were women), the "mad blood" had stirred to such an extent as to get them into the hands of

the law. During the same period 3,564 (2,467 males and 1,097 females) had been placed under surveillance by the police in initial attacks of insanity. Of suicides (and unsuccessful attempts) the police records showed 2,946 for the period.

Arrests for drunkenness were shown to be 44,495.

But the police blotters are not our only records of human conduct. The records of certain public schools gave 108,020 absences and 14,083 cases of discipline for various misdemeanors, and those of the City Penitentiary on Randall's Island 3,981 more of the latter.

To show the influence of weather conditions on health, a portion only of the twelve-year period was covered, and it was found that 75,486 persons had been treated in the outpatient department of the Roosevelt Hospital; 191,137 single day's absence from duty by members of the City Police Force were recorded, and 74,793 deaths were reported for the city; in all more than 550,000 separately recorded human events with the exact date of each, and by reference to the weather data already discussed, the exact meteorological conditions under which each occurred were determined.

It is unnecessary to describe the method of tabulation followed other than to say that for each peculiarity of conduct studied, *i.e.*, assault and battery, suicide, drunkenness, etc., two curves were plotted: Expectancy based upon the percentile prevalence of definite meteorological conditions (the same for all), and occurrence based upon the percentile prevalence for each condition of the abnormality of conduct being considered. If 6 per cent. of all the days showed a mean relative humidity of .75 to .80 and 9 per cent. of all suicides occurred under those conditions of relative humidity, suicides were 50 per cent. in excess (9 per cent. = 100 per cent. + 50 per cent. of 6 per cent.), and so on for them all.

The results show conclusively that Shakespeare and the rest were right.

As to "hot days" and "mad blood," had Mercutio but followed Benvolio's sage advice, the plot might have been despoiled of all its tragedy, for our study showed an excess of arrests for assault and battery of 69 per cent. for men and exactly 100 per cent. for women—or double the expected number—on days when the mean temperature was between 80 and 85 degrees Fahrenheit. The curve is so regular as to leave no doubt of its validity, starting in with a deficiency of 50 per cent. at 10 degrees F., reaching normal (the expected number) at 60 degrees F., and ascending rapidly as the heat increases to the excesses mentioned above. But at this point (*i.e.*, 80 to 85 degrees F.) a strange thing happened to the curve. For the temperature group 85 to 90 degrees F. it suddenly drops, for the women to an actual deficiency of 30 per cent. and for the men to an excess of only that magnitude. Seemingly, something more is necessary for a fight than mere emotional disturbance. One must not only feel like fighting, emotionally speaking, but also feel like fighting, physically speaking, if real blows are forthcoming, and it would seem that the excessive heat of 90 degrees F. had effectively robbed everybody of the latter. Doubtless, if it were of mere profanity that we had a record, and not blows struck, the results would be different.

In the case of drunkenness, the effects of the hot day are almost diametrically opposite to those for assault. Here the curve starts from excess of 40 per cent. at the temperature of 10 degrees F. and runs down, with minor fluctuations, to a deficiency of 30 per cent, at 85 degrees F. This was a distinct surprise to me—though the whole study was full of surprises—for I had lived a number of years in the tropics and found it to be the prevailing opinion that one does not

"carry" his liquor there as well as in colder regions.

But it is certain that the low temperature booked the drunks in New York City. Several influences may have weight here. Our long winter evenings are more conducive to conviviality than are the shorter ones of summer; but I am wondering if there is not a suggestion here to those interested in the solution of our liquor problem. Other phases of the question of weather influences—not discussed here—seem to show that during low temperature the reserve energy of the body is relatively deficient. This would affect the demand for a stimulant. A "bracer" is taken when *needed*, and for many a "bracer" means a "drunk." We may, I believe, with justice, conclude that many of the habitués of the police court as prisoners struggle against their tendencies to drink, knowing the consequences. When vitality is excessive, they do so with success; for days and, perhaps, for weeks they are winners, but finally the time comes when the fight is too severe, and they succumb. That was on the day when the vitality was at its lowest ebb, and the cold contributed to that condition. A few glasses of whiskey would remedy all that, and it did so. What cared the poor fellow what Arctic explorers have said about the effect of alcohol upon the system in the long run? He was cold; he was weak. The stimulant would give him immediate, though temporary, relief. He took it, and our figures show the result. Who can say how largely the drink problem is one of better heated tenements, of warmer overcoats and of more nourishing food!

Now we are between the devil and the deep sea. If we want to keep from fighting we must take care on a hot day, and if we want to keep sober we must look out on a cold one. But there is one consolation; if we want to commit suicide neither one seems to have anything to do with it—at least until we reach that deadly point of 90 degrees F. as a mean for the day.

Suicides were found to be precisely normal in number at a temperature of 15 degrees F. and again at 75 degrees F., and between those two points the curve fluctuated in such a manner as to indicate little or nothing. At 90 degrees F. it took a jump to + 45 per cent. for men and + 70 per cent. for women, but there were so few cases involved at this extreme of the curve as to lessen its value.

So when it comes to committing suicide we may do it on any kind of a day, so far as the thermometer is concerned, without violating the rules of this paper.

But when it comes to certain other meteorological conditions, we must take care. For instance, we must consult the barometer, to do it according to form.

For every barometrical reading above 29.80 the number of suicides was deficient, running down to — 88 per cent. at 30.30, while for every reading below 29.70 it was excessive, averaging + 176 per cent. (nearly three times the expected number) for all readings below 29.60.

Just what this means it is not easy to say. Certainly it is not a matter of mere atmospheric pressure, for every time a New Yorker goes to the Catskills or the Adirondacks he experiences a greater lessening of pressure than is shown by the extremes mentioned above, seemingly with no suicidal effects. It is, however, a well-known fact that low barometric readings generally precede storms, and here we may have the explanation.

If so, they had the thing over before the storm really struck, for in a most surprising way, suicides chose the most delightful of all our weather conditions for their fatal act. The month of May is their favorite, with an excess of 90 per cent. for the women and of 12 per cent. for men. Twenty-five per cent. more chose dry days for the act than

rainy days, while 22 per cent. more chose clear days than those characterized as partly cloudy. The number choosing cloudy days was precisely normal.

Wind alone among the more evident meterological conditions proved an exception to the seeming desire to leave the world on a pleasant day. Excessively high winds proved deadly. Starting in at — 80 per cent. at wind velocity of 2.5 miles per hour the curve rises almost without fluctuation to + 200 per cent. (three times the expected number) for days on which the average hourly movement for the day was fifty miles.

This seems as it should be.

But how account for the excess of suicides on the most delightful days of the whole calendar? To me the only plausible hypothesis is that of contrast. Investigation has seemed to prove that very few suicides are committed on the "spur of the moment." The act is generally premeditated and its consummation deferred, sometimes again and again. We can hardly doubt, either, that it is dreaded, and the hope entertained, even to the end, that it may not need to be. During the winter months that hope might be centered in the belief that when nature smiles with the spring sunshine all will be well; on the gloomy day, when the morrow comes with its exhilarating brightness, the present cloud of unhappiness will be gone. The love of life is still strong, and the grave can not be sought while there is still hope for better things.

Spring comes with all its excess of life, and the morrow with its brightness, but do not bring to the poor unfortunate, unable to react to these forces as of yore, the hoped-for relief. He thinks of other springs when the bluebirds sang happier songs and of other sunshine which had set his blood a-tingling. The drowning man had waited long for the straw; it came and he clutched it, but it sank beneath his weight. Dante felt the force of it when in his "Divine Comedy" he wrote:

> No greater grief than to remember days
> Of joy, when misery is at hand.

And Tennyson expressed the same thought in "Locksley Hall":

> Comfort? comfort scorned of devils! this is truth the poet sings,
> That a sorrow's crown of sorrows is remembering happier things.

So much for voluntary death.

How about the other kind?

This takes us into a brief discussion of body energy. Health means a degree of body energy based upon metabolic processes, the activity of which has been determined by natural selection through a long period of time. When those processes are normal, a sufficient modicum of energy is developed for all the vital activities of life—respiration, circulation, digestion, assimilation and excretion—plus a reserve of varying quantity available for the higher and more recently acquired activities of the race, such as the mental, the emotional, etc. When the production of body energy is insufficient for the demand of the vital processes, ill health and possibly death ensue. Seemingly, when the production of energy is in excess of that required for the vital processes it is available as excess energy and affects conduct in its accepted sense. A horse fed oats in the stable for a month is likely to be frisky. But oats are not the only thing that will make a horse frisky. The weather will do it. I once studied the occurrence of several hundred "runaways" with respect to the weather and found this to be true.

From the standpoint of energy, there is no difference between the "runaway" for a horse and a fight for a man or perhaps naughtiness for a child. Each must "feel his oats" before he does it. Does the weather make us feel our oats?

In other words, do varying meteorological conditions affect the production of body energy?

We have four sets of figures which have a bearing on the answer to this question: absence from school on the part of pupils; absence from duty on the part of policemen; attendance at the hospital clinic, and death. The first two and the last would, in general, be due to low vitality. There is no doubt as regards death, save in cases of accident, and as to the others contagious diseases and perhaps circuses might have to be reckoned with, but in general the law would hold there.

With attendance at the hospital clinic, I am inclined to think that the reverse is true; that those who are patronizing the clinic—and the records show the average number of visits on the part of such to be four, made at intervals of some days—only attend when they feel equal to the inconvenience of such a visit; that is, on the best days which they experience. If this be true, we should expect the curve for hospital attendance to run counter to the other three. And that is what it does.

It would be too long a story to go into the detail of it all, but in general temperature seems to have little effect on health until we reach the highest degrees, when everybody wilts. It is not strange that moderate degrees should not be felt, since the temperatures in which we live—except the highest—are artificially controlled. One might be sick for days in the dead of winter without knowing that the thermometer outside registered zero, except for the frost on the window. Extremely low barometric pressure is deadly, with a similar effect, though to a lesser degree, for extremely high readings. Moderate atmospheric pressure is healthful. High humidity is disastrous, while the same is true for virtual calms and also for the other extreme of wind movement. Neither the character of the day nor precipitation has any marked effect.

No one of the meteorological conditions studied more plainly differentiates the different classes of data into contrasting groups than does the wind, and no condition presents more anomalous and unexpected effects. Particularly is this true for movements of less than one hundred miles for twenty-four hours—that is, virtual calms.

Misconduct cases in the public schools on such days were but 50 per cent., and in the penitentiary 80 per cent., of the expected number; women arrested as insane 34 per cent., men 67 per cent.; suicides 62 per cent.; arrests for drunkenness 78 per cent.; for assault and battery, women 45 per cent. and men 89 per cent. With death we reach the first excess over expectancy, with 104 per cent. Policemen off duty 105 per cent.; sickness (hospitals) 114 per cent., and absence from school 314 per cent.

The striking thing about the curves on which these figures are based is the sudden change which takes place in the occurrence of nearly all the activities (or cessation of activity as in the case of death) with a slight increase in wind.

Calms are in a class by themselves so far as wind effects are concerned. During their prevalence certain phenomena suddenly increase in number, while others drop almost to a vanishing point. Those in excess are absence from school, absence from police duty, sickness and death.

But absence from school means sickness, absence from duty the same, and death the same at its maximum—that is, depleted vitality in every case.

Those human events which were deficient during calms were, without exception, misconduct cases: arrests every one of them, either by the police or school authorities, and due for the most part at least to a surplus of energy.

Let us see if that is not so.

In the public schools, sins of commission, rather than sins of omission, are usually the occasion of bad marks in deportment. It is usually the active, energetic boy, the one with vitality to spare, who gets the demerits. The anemic youngster may never stand at the head of his class, but he is very likely to delight his fond mamma with a mark of 100 in deportment. If that be so, and I speak with authority upon this point, if upon no other, disorder in the schoolroom is an active thing and an evidence of excessive vitality. With the penitentiary inmate I have had less experience, but upon *a priori* grounds would argue that what is true for the child in questions of deportment would not be radically different for the adult. In fact, the wardens in charge, upon being questioned on the matter, gave it as their opinion that the prevalence of disorder bore a pretty close relation to physical health, varying directly with it; that order was only observed through evidence of superior force on their part; that a sick person was always a good one, but that with return to health, conditions were frequently very different. We may, then, conclude that in the penitentiary misdemeanors are evidences of excessive vitality.

With persons arrested for the crime of assault and battery the same is, I believe, demonstrably true. One might feel like fighting, and perhaps more frequently does feel so, when possessed of "that tired feeling" which is the fortune of patent medicine venders, but to *feel* like fighting without doing so never brought a man before the police judge for the crime which we are considering. There must be both the inclination and the consciousness of strength to back it up before one would be likely to figure in this class of data.

In the case of the next class, that of arrests for insanity, we shall take the word of the psychiatrist that acute mania increases with any condition which tends to augment the output of nervous energy. The daily fluctuations in strength which all have experienced are not so much those of physical, as of nervous energy, if the distinction may be made, and with persons having tendencies to mania the results would be those which our records showed.

Drunkenness and suicide are not so evidently manifestations of superabundant vitality—though, as I have already shown, the latter is excessive under the most exhilarating conditions—yet with these possible exceptions it would seem that during calms those life phenomena which normally are due to an excess of vitality are deficient in number.

Why?

Merely, it would seem to me, a question of ventilation. Not of opening a window to let in some good air, but perhaps of opening a window and finding no good air to let in. Remember this study is confined to New York City. And then remember what New York City is. Some millions of people burning up oxygen and some hundreds of thousands of furnaces and fires of smaller dimensions doing the same thing, all pouring forth carbon dioxide without sufficient vegetation to reverse the process. What else could be expected, without a little breeze to carry it out to sea, or over to Jersey where the trees can take care of it? Studies made in the city of Manchester, England, to determine the relative prevalence of carbon dioxide on calm and on windy days show that the quantity is several times greater under the former than under the latter conditions. With an excess of that deadly gas, the production of body energy slows up with the result that we have noted. So, if you live in a large center of population take to the woods on a calm day. It is safer.

In conclusion, it seems safe to say that Shakespeare was right, not only in his

allusion to the deadly effects of a hot day, but in his many other references to weather influences. And so were the others who have embodied their impressions in literature. Once more, all honor to the seer who does not need to follow the empirical method, for after all research is seldom more than an attempt through scientific process to verify or disprove somebody's impressions.

The varying meteorological conditions that we call weather do influence us to marked degree, seemingly through a direct effect upon the metabolic processes of life. Seemingly, too, women and children are more susceptible to them than are men.

We can not change the weather, but we can perhaps adapt our activities somewhat more to its decrees, if only the latter be known.

In our public schools are more than twenty million children under controlled conditions. We have shown that under certain weather conditions so much energy is produced that it blows off in misconduct.

But why in misconduct?

It is a question of energy. Why not open some safety valve on such days and let the surplus escape?

A longer recess might do it or calisthenics or anything else that will burn up the excess.

But, you say, must the teacher consult the weather report before arranging the schedule for the day? Not that exactly, though it may come in time. But when we as fathers and mothers and teachers and common everyday individuals get to be as wise as that group of teachers in Colorado and then just so much wiser as to lead us to act in accordance with the facts, we shall not attempt so many impossibilities, either with ourselves or with others.

For:

> . . . a breath thou art,
> Servile to all the skyey influences
> That do this habitation where thou keep'st,
> Hourly afflict: . . .
>
> "Measure for Measure," Act III, Sc. 1, 8–11.

THE TREND OF PUBLIC HEALTH WORK: IS IT EUGENIC OR DYSGENIC?

By Professor MAZYCK P. RAVENEL
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NEVER before in the history of the world has there been such an intensive campaign to prolong life. Our success in the control of communicable diseases has been outstanding along every line, except for the respiratory infections. Education in personal hygiene is making good advances. New discoveries in problems of nutrition and the value of foods have been revolutionary. Physical education has been so magnified that it threatens to overshadow mental training in our schools and universities. Along with these advances, there has been an equal improvement in our environment. The development of transportation, cold storage and other methods of food preservation have taken away from the world in general the specter of famine. Along every line the stage has been set for such rapid increase in population as no one ever before thought possible. Success has attended our efforts. Our increases in population and resources are being preached from the housetop, and if success means the accomplishment of our objects, we certainly have the right to boast. In the midst of rejoicing by sanitarians, humanitarians, business men and powers which need "cannon fodder" a note of question is creeping in, coming chiefly from biologists and a certain class of economists. Can we accept the dictum of Adam Smith that "the most decisive mark of the prosperity of any country is the increase of the number of its inhabitants?"

Increase in population according to this idea means progress. Ambassador Bryce once stated "that the ultimate test of every kind of advance is happiness." Malthus pointed out long ago that increase in population that was out of proportion to the increase in food supply would lead to anything other than happiness. His doctrine was received with incredulity and worse, but each year proves his wisdom and foresight, and there is a constantly increasing number of studious men and women who are accepting his views and advocating measures based upon their practical application.

We do not know how long man has inhabited the earth, but we do know that in 1800 the population of the world was approximately eight hundred and fifty million and that this number was doubled in the last one hundred years. Taking the smallest estimate, which is scouted by almost all scientists as being twenty-five thousand years, we can say that it has taken only one hundred years to double the population which it required twenty-five thousand years to produce. Knibbs estimates that the population of the world doubles every sixty years at the present rate of increase, and if this is true, within three generations from the present our population will reach seven thousand million, or two thousand million more than the estimated number for which the world can produce food.

Preventive medicine as we know it today is of recent birth. While Pasteur began his publications about 1855 to 1860, his discoveries became generally known and utilized less than fifty years ago. The application of his discoveries has meant almost more to big business than to humanity. Vast areas of tropi-

cal and semi-tropical countries which only a few years ago were sealed against exploitation are now open for the production of rubber, coffee, tea, spices and other products of world-wide consumption. The result has been that in these areas the population has increased one hundred and five million. Forty years of British rule in Egypt saw the population of the Nile Valley double. In approximately the same length of time India has added fifty million to its already overcrowded population, and the most expert students now question whether or not the masses in India are better off than they were before British rule, yet we know that the British have introduced modern methods along practically all lines. Approximately the same statement can be made of many parts of the world, and the estimate of Knibbs for the world has been far surpassed in many countries. In the Philippines the increase from 1908 to 1918 was at a rate which would double the population in twenty-three years. The population of Java has multiplied eight times in a century. In Porto Rico, where the birth and death rates were approximately balanced, we have since 1900 reduced the deathrate to eighteen, while the birth-rate has risen to thirty-seven per one thousand. Next to Java, this is the most densely populated agricultural area in the world—nearly four hundred to the square mile. Between 1800 and 1916 the population of Europe increased from one hundred and eighty-seven million to four hundred and sixty-five million.

We are naturally more concerned with our own country than with the rest of the world, in spite of the fact that our charities are reaching out to every land. The United States increased its population almost twenty fold between 1800 and 1920. For the decade from 1800 to 1810 only 1,932,000 were added, while for the decade from 1910 to 1920 the increase was 13,739,000. The latest estimate by the United States Department of Agriculture is "that after our arable land has increased almost 100,000,000 acres, which appears likely to happen during the next seventy-five years, and if our acre yields of the crops attain those in northwestern Europe, and our diet reaches the pre-war German standards, our nation will be able to support about three hundred million people." That these conditions will be fulfilled is very uncertain. The population of the United States increases by about one million five hundred thousand yearly, while the yield of foodstuffs per acre has shown little or no increase for fifteen years past. Dr. Baker, who has made this study, contradicts Adam Smith and says that "strength is measured more by per capita wealth and welfare than by numbers of people."

From 1804 to 1914 the rate of increase of population in the world was 0.844, which would lead to a doubling of the population in 80.57 years. Between 1906 and 1911, twenty-six of the leading countries of the world increased at a rate of 1.159, which would double the population in a trifle over sixty years. Taking the world population in 1924 as 1850 million, either one of the above rates would lead to saturation of the entire world by the year 2165, approximately two and a half centuries. As far as we are able to judge from the past, and with our present knowledge, it is safe to say that our present rates of increase must fall off as the population approaches saturation. Every year will show advances in sanitary science and in control of diseases of almost all kinds, so that the decrease must come by limiting the birth-rate or by the destruction of life. The birth-rates of practically every country from which we obtain reports is decreasing, in spite of which all our populations are increasing at a rate

which must cause grave concern for the comparatively near future.

The world must live chiefly by agriculture. Consequently, the best distribution of population is that which conforms most closely to resources. Where great differences exist, migration is the only relief, but the necessity of migration means racial jealousies and war, which is not only inhuman, but as we have had recent cause to learn, economic madness. As our population increases, we will be compelled to depend more and more on vegetable foods, and fewer animals will be raised either for food or for transportation, since the land will be needed for vegetable food production.

The history of the world shows that civilized people do not hesitate to take territory from inferior races, with the result that the latter often disappear more or less completely. Striking examples of this are seen in our own country, in South Africa and in Australia.

We can not foretell what future discoveries will bring about, but it is hardly conceivable that such advances in the production of foods will be made as to entirely upset the calculations based on our present knowledge. Making every allowance for increase of knowledge and for improvement in our social, economic and political organizations, Knibbs, the noted Australian economist, calculates that seven thousand million population may be supported, while ideal conditions which are most improbable may possibly allow from nine thousand million to eleven thousand million. With our present standard of living, it is doubtful if the world can support five thousand million people.

The title of my paper would scarcely seem to justify the discussion up to this time, but food is the primal necessity of all living beings, and the discoveries of the last few years have shown us that quantity is of relatively less value than quality in regard to certain contents. It is impossible therefore to consider the welfare of the race without taking into consideration what our present rate of increase is leading to in the way of overcrowding and struggle for existence.

It has frequently been pointed out that the prolongation of life, of which we have boasted so much, has been chiefly in children under five years of age. On the one hand, it has been claimed that the saving of weaklings is bound to affect the future of the race. On the other hand, there are those, notable among whom is Sir Arthur Newsholme, who hold that the struggle of the survivors among those in whom a high death-rate occurs, is severe and leaves its mark. While we may admit with notable statisticians that infant mortality is to a certain extent selective, the predicted compensatory death in early life from the saving of babies otherwise doomed does not occur, since the mortality rate has improved at all ages except the very advanced. Quite a list of world shakers could be given among those who would have been selected for weeding out, if such a system had been in vogue.

The present state of our knowledge does not permit of the formulation of rules for the future, but it is not too early for us to begin a careful study of the situation which confronts us. American beneficence has founded a modern medical college in China, already overpopulated. Highly educated medical missionaries are going to many parts of the world which already have more people than they can support. In a few instances agricultural missionaries are also being sent. The medical section of the League of Nations is collecting data from practically every part of the world and giving the results to all nations. This can not but result in the saving of lives at all ages with an increase of an already superabundant population. America has found it necessary to re-

strict immigration, though many believe that this has not gone far enough. There is some reason to believe that it will cut out at least one source of undesirable stock.

While acknowledging our inability to suggest a complete program for the future, there are certain outstanding facts upon which we should act promptly. The World War gave us our first opportunity for the examination of a large number of our young men. It astonished many to learn that if mental deficiency runs uniform among persons of all ages, there would be 353,210 male defectives in the United States. Supposing the same number for females, we would have more than seven hundred thousand for the country, less than 6 per cent. of whom are cared for in institutions, which means that approximately 94 per cent. of these defectives are at home living without restraint of any kind. Judging from known facts concerning those in institutions of various kinds, it is conservatively estimated that there are between one and one half and two million people in our country who are defective and in need of institutional care, of whom at least one half have heredity to thank for their condition, and who in turn will reproduce their kind. East, who is somewhat pessimistic, estimates that we have "people with no sense worthy the name, defective stock, over five million; people with little sense, scrub stock, twenty million."

The fecundity of this class of people is in no doubt. In spite of a high infant death-rate and a greater amount of sterility, there seems to be no doubt that the subnormal reproduce their kind more abundantly than the normal. In St. Louis among normal families only 4.76 per cent. had eight children or more. As the mental scale went down, the size of the family went up, so that among morons 34.58 per cent. of families had eight children or more, while for all classes of those below normal the average was 19.12 per cent. When we remember the number of criminals who are subnormal, and that subnormality leads to criminality, and when we know that a large percentage of asylum patients are released and recommitted, some of them twenty-eight or thirty times, we are surely not going too far in believing that genuine humanity, as well as common sense, demand that we place some restriction upon these afflicted persons. As far as we are able to judge, the deadly deteriorative character which is so clearly seen in most of these cases can be gotten rid of only by cutting the bearer off, and there is no justice in giving them the same privileges as are enjoyed by the normal. The difficulties in the case are acknowledged to be great, but this is all the more reason for taking hold of the matter promptly.

Recently a more optimistic attitude towards the feebleminded has been taken. The late Dr. Fernald, than whom no one was more competent to speak, held that only about 10 per cent. of the feebleminded are anti-social and vicious. The remainder can be handled and many of them made useful citizens within their class by education and supervision. Those who are trained do not differ markedly from normal people in respect to the number of children they produce. In view of the fact that only about 50 per cent. of the feebleminded are such through the inheritance of defective germ plasm, and that there is a tendency for the inheritable healthy qualities of germ plasm to outnumber and gradually supersede the unhealthy traits, it is possible that the offspring of such people through several generations may improve. For those feebleminded whose condition is due to post-natal conditions, no special precautions are required in this respect, since acquired characteristics are not inheritable. As Professor Conklin says: "Wooden legs are not in-

herited, but wooden heads are." Fernald's estimate of the number of feebleminded is, however, considerably greater than that shown in the draft figures quoted above, if we may apply to the whole United States those given for Massachusetts. In that state, with a population of approximately three and one half million, there are at least sixty thousand intellectually subnormal persons. For the entire United States this would give a figure approaching two million. Quite recently Dr. George K. Pratt, of the National Committee for Mental Hygiene, has emphasized this more hopeful outlook. The 10 per cent. of feebleminded who are vicious is found almost exclusively among the neglected, most of whom, if given a fair opportunity by training and supervision, would lead well-behaved lives. A recent survey in New York shows that only 7.6 per cent. of the jail and penitentiary inmates studied were definitely mentally defective, and the addition of the borderline and dull-normal groups only brought the total to 20.3 per cent.

He endorses the program first proposed by Fernald, which may be summed up as identification, registration, education, training, supervision and permanent segregation for defective delinquents and the lower, helpless group of feebleminded. Sterilization is definitely rejected as a solution of the problem.

In thinking of this subject, too many people are inclined to consider only such evident cases as are more or less apt to come under official recognition. There is, however, a large class made up of people who are often extremely likable, attractive and who are ordinarily free from criminal tendencies. They are, however, mentally incompetent to make a living or to realize the responsibilities of life. They are easily led and sooner or later are apt to drift into lives which bring them into the criminal courts. These people marry—or do not marry—and beget their kind indiscriminately. It is always a matter of comment that so much more is done for animals than for humans. Those who resort to every sort of quackery for themselves and their children demand the best educated veterinarians and use the most modern methods in caring for their flocks and herds. The same thing holds in regard to eugenics. In breeding live stock, the selection of the parents is a cardinal principle. The veriest tyro knows that animals are not born equal. The good livestock breeder selects the best and makes sure that the inferior animals leave no progeny. Only those—and there are none who are competent to speak—who deny the overwhelming influence of heredity deny these facts and use inferior animals as breeding stock. We do not pretend to put the lower animals on the same level with man, but there is no doubt that we could learn some useful lessons if we studied the lower animals and the methods of stock-raisers a little more closely. Religion, race, customs, emotions and humanity all influence us. It is a poor humanity which allows the propagation of the unfit.

Among the remedies for over-population with its many attendant evils, birth control seems to be the most popular at the present time. It is one of the foremost questions in England and has gained great headway in America. It is within the truth to say that it is endorsed by practically all the leading biologists of the country, by many economists and sociologists and some clergymen. In England it has the support of many clergymen of high standing. Some of the arguments for birth control must appeal to every thoughtful person. Every child in a small family is brought up on a higher standard of living, receiving proportionately a greater amount of attention and has opportunities for a better start in life. The argu-

ment that the health of the parents of small families is better does not seem to be entirely sound, but where the choice lies between abortion on the one hand and birth control on the other, this argument may hold true. On the other hand, the objections to birth control are too manifest to be passed over lightly. It is already being practised in one way or another by those best fitted to perpetuate desirable families. Any restriction which would reduce the number of offspring of desirable parentage below the minimum required for the perpetuation of the stock is bad from every standpoint and is more apt to lead to the loss of good stocks than to prevent the perpetuation of poor ones. The preservation of good stocks is immensely more important than the prevention of increase among the inferior.

We do not know enough to speak positively of the advantages of the small family. Many notable persons have been members of large families and have been well down in the long list of children. Sir William Osler was one of these, the youngest in a family of nine. The small family idea proposed by the Neo-Malthusians would have deprived the world of many of its greatest lights. The whole question is bound up with religious, social and economic conditions. It offends certain churches particularly, but generally speaking all Christian churches as well as the Jews condemn interference with procreation. If we believe this to be a true picture of the situation, we must of necessity stand against it, at least until we know a great deal more than we do at the present time.

The answer to the question propounded in the title of this paper is not clear. From the biological standpoint there seems no possibility of producing a superman. We tend to mediocrity through the very fact of the large number of ancestors each of us have. If the best could be mated always with the best, unquestionably we could produce results similar to those seen in the breeding of the lower animals and of plants. Eventually all the offspring would tend to be superior and the superiority would be maintained as long as this type of mating was kept up. It seems impossible ever to expect anything of this sort.

We must conclude, then, that our present measures will continue to save more and more lives. The good and the bad will alike be saved. Our present standards will not permit of any lessening of our attempts to save lives and better conditions, nor do any people exist who would propose a lowering of standards. Within the next few hundred years the problem of overcrowding will have reached a point requiring attention and a change in attitude will almost certainly be noticed.

HOW FOSSILS GOT INTO THE ROCKS[1]

By Dr. WENDELL P. WOODRING

U. S. GEOLOGICAL SURVEY

Fossils are the remains or traces of animals and plants that formerly lived on the earth. A footprint, a leaf imprint and a worm burrow are fossils every bit as much as bones and shells. Nor is it essential that these remains be turned to stone. Many animal fossils consist of the same material found in the hard parts of living animals, but other fossils are completely changed to stone or the original material may have disappeared, leaving only a mold. Fossils may be of any age. They may have lived millions of years ago, or they may be only a few years old. An example is shown by the limb bone of a cow that was found partly buried in the ground. The part below the ground was petrified and was as stony as any ancient fossil, but the part above ground was entirely unchanged, except that it was weather-beaten. On some of the West Indian islands stretches of beach can be found that are changed to limestone rock, but the shells and other remains buried in the solid rock are perfectly fresh and the dried skin still clings to some of the shells, showing that the beach was transformed to rock only a few years ago.

At many places fossils are so abundant that they naturally attracted attention long before the rise of modern science. During this period many curious beliefs arose as to how fossils got into the rocks. By some they were regarded as the results of some mysterious force that arose from the earth or the stars. Others thought they were freaks of nature or models discarded by the Creator. And others considered them convincing evidence that at one time the earth was devastated by a flood. One enthusiastic supporter of this belief found some bones that he was convinced were the remains of one of the wicked men, whose sins brought upon the world the dire misfortune of the deluge, and he named these remains "The man who witnessed the flood" at least that is the English equivalent of the Latin name. As a matter of fact it was later discovered that these bones belonged to an extinct giant salamander. Another supporter of this belief concluded from a study of fossil fruits that the deluge began in autumn. A learned professor, who believed that fossils were formed by the earth, carefully described as fossils an amazing array of suns, moons, stars and Hebraic letters that his students planted in quarries. When he dug up his own name the secret was out and he vainly attempted to buy up and destroy all the copies of his book. Leonardo da Vinci, the great Italian artist and engineer, was one of the first to show in a convincing manner that fossils are the remains of animals and plants that actually lived where they now are found. Although some people even now believe that fossils were put in the rocks by the devil to confuse man and others still believe that they are sure signs of wholesale destruction by a world-wide deluge, it is clear that they get into the rocks by natural means —by means that can be seen in operation now.

Every one knows that when animals and plants lie on the surface of the ground after death they gradually decay and crumble. In order to be pre-

[1] One of the Smithsonian series of radio talks arranged by Mr. Austin H. Clark and broadcasted from Station WRC, Washington.

Courtesy of American Museum of Natural History

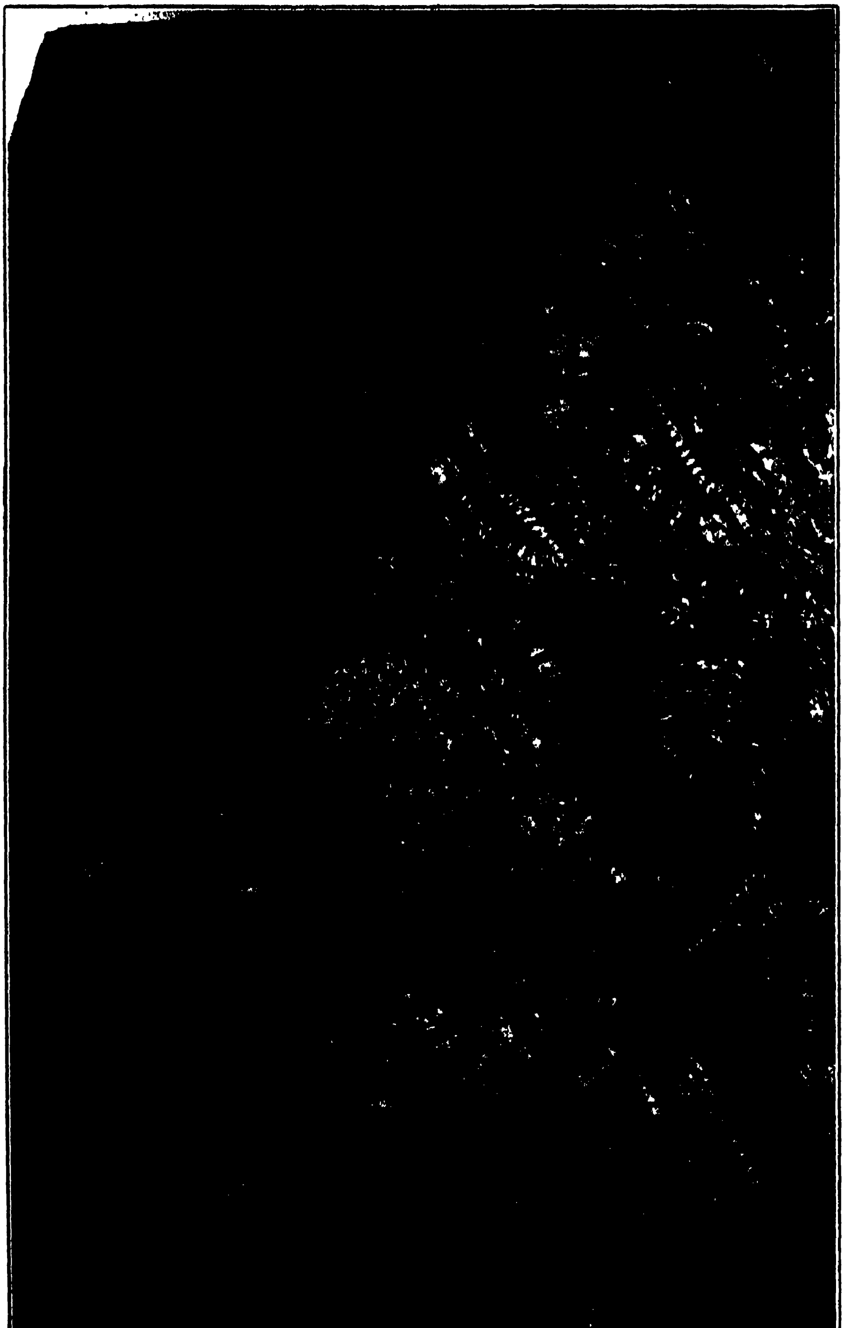
THE ASPHALT POOL AT RANCHO LA BREA, CALIFORNIA

A GROUND-SLOTH IS TRAPPED IN THE STICKY ASPHALT. TWO OTHER GROUND-SLOTHS ARE READY TO DEFEND THEIR COMPANION AGAINST THE SNARLING SABRE-TOOTH TIGERS. IMPERIAL MAMMOTHS AND GIANT WOLVES CAN BE SEEN IN THE DISTANCE. FROM A MURAL IN THE AMERICAN MUSEUM OF NATURAL HISTORY PAINTED BY CHARLES R. KNIGHT UNDER DIRECTION OF HENRY FAIRFIELD OSBORN.

U. S. Geological Survey

A PETRIFIED TREE TRUNK IN YELLOWSTONE NATIONAL PARK

THIS TREE, WHICH IS STANDING WHERE IT GREW, WAS BURIED BY SHOWERS OF ASH FROM VOLCANOES.



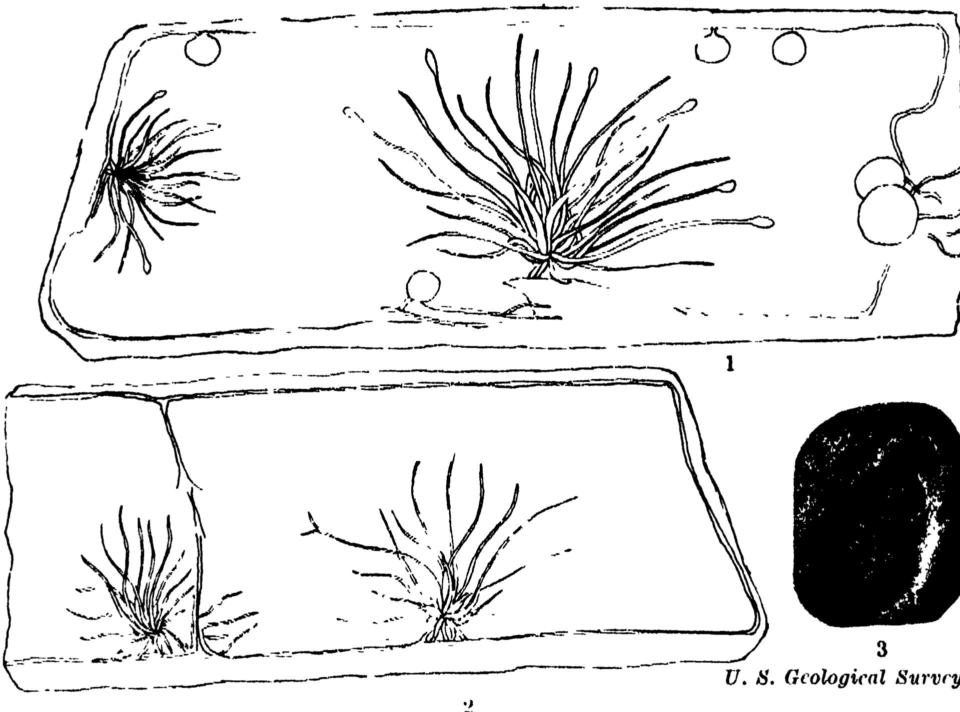
Smithsonian Institution

MIDDLE CAMBRIAN SEA ANIMALS FROM BRITISH COLUMBIA

TRILOBITES AND CRABS FROM A FAMOUS LOCALITY DISCOVERED BY DR. C. D. WALCOTT, SECRETARY OF THE SMITHSONIAN INSTITUTION.

served as fossils it is essential that they be buried. Only the hard parts of animals generally are preserved, for the soft parts are eaten by scavengers or decay. Under exceptional conditions the soft parts are found in virtually perfect condition. In the frozen ground of northern Siberia specimens of elephant-like animals, called mammoths, and of the wooly rhinoceros, both of which lived during the Ice Age, are found with flesh, hair and wool preserved. The flesh of these animals can be eaten, although they have been in cold storage for something like fifteen thousand years, which is a record for cold storage meat. The contents of the mouth and stomach of the Siberian mammoths even show what kind of plants these animals fed on. A less perfectly preserved mammoth having parts of the flesh and hair intact has also been found in Alaska. Though actual flesh is found only in these relatively recent fossils, the skin of much older animals may be preserved because it was thoroughly dried before the carcass was buried, and the muscle fibers of some very ancient fish can be recognized on account of the replacement of the soft tissue by mineral matter. When worms and other soft-bodied animals are quickly buried by mud that prevents bacterial decay, they leave impressions that may show not only the surface but also the internal structure. Such fossils are found even in very ancient rocks, but they are rare.

The most abundant fossils are the remains of animals and plants that lived in the sea. No matter whether they live on the bottom of the sea or on the surface, the hard parts of sea animals collect on the bottom after they die and after the scavengers have done their work. There they are covered by gravel, sand or mud carried in by streams and washed about by the sea. Any one who has walked along a beach can see that shells and other remains that are rolled by the waves are badly battered and broken up. Such battered fossils are found in ancient beach deposits. If the remains are buried in quiet water or at a depth beyond the effects of waves the fossils may be as perfect as the same parts in living animals. In the deep ocean basins, where deposits accumulate very slowly, the teeth of giant sharks and the ear bones of whales, long extinct, may even now be only partly buried. Many sea animals and plants die and are buried at the place where they lived. Corals and other reef-making animals and plants are killed by changes in the temperature or depth of the water, or are smothered by mud and sand. Incredible numbers of fossil fish are found in thin layers of rock in California and at other places. They probably were killed by being stranded in shallow bays into which they were driven by their enemies or during storms, just as herring are sometimes stranded by millions in our northern harbors. The decomposition of the stranded fish pollutes the water and kills other sea animals, all of which would become fossils if they were buried before they completely decayed. Complete skeletons of sea mammals—whales, dolphins, porpoises, seals and walruses—generally are rare, for the bloated carcasses float on the water and the bones are scattered, but at places, such as a famous locality in Belgium, many carcasses drifted into a cove and were stranded and buried there. Remarkably perfect sea reptiles showing the outline of the body, which also represent carcasses stranded in fine mud, are found in England and in southern Germany. When any of these deposits that were laid down in the sea are brought above sea level by elevation of the land or by retreat of the sea, the fossils can be seen embedded in the rocks, although the originally loose deposits may be changed to solid stone and the fossils themselves may be completely altered.



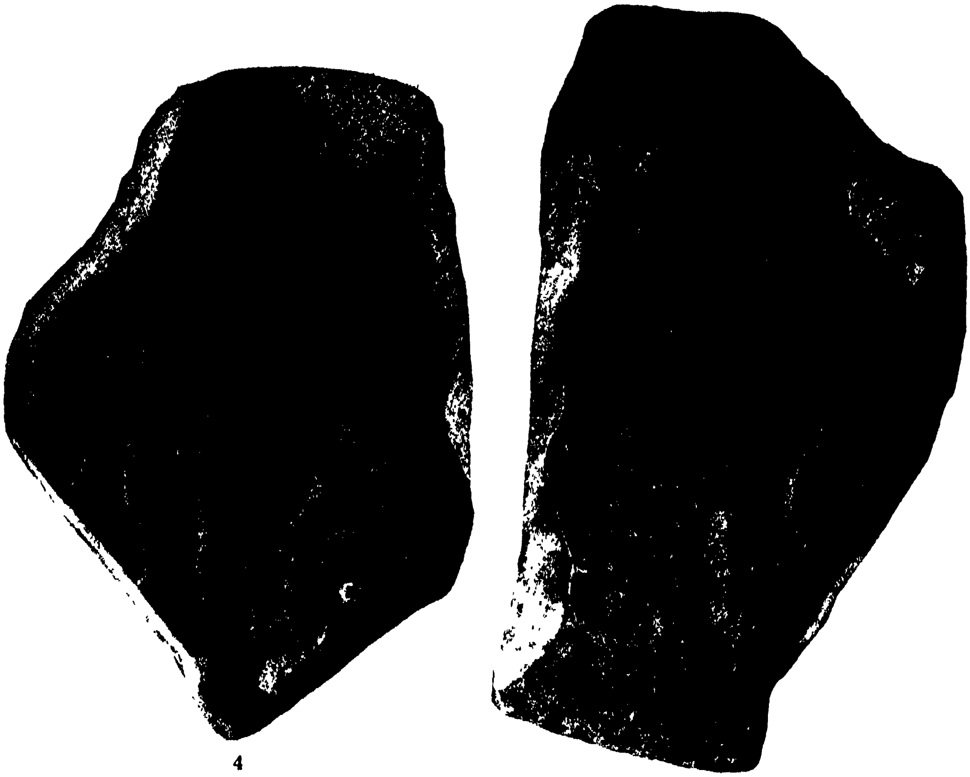
U. S. Geological Survey

FOSSIL PLANTS OF EOCENE AGE FROM TEXAS AND LOUISIANA

FUNGI PRESERVED IN PETRIFIED WOOD (FIGS. 1 AND 2), A CONE (FIG. 3).

The bones and teeth of land animals are buried in stream and lake deposits, or by showers of volcanic ash and by wind-blown sand and dust; or the animals are bogged in mud holes and trapped in quicksand. Fossils in coarse stream deposits, like fossils in beach deposits, are worn and battered. At a locality in western Kansas the skeletons of nine peccaries, or American wild pigs, were found crowded together with their heads all pointing in the same direction. These animals apparently were killed and buried by a sand storm. The wind-blown dust deposits of the pampas of Argentina contain many queer-looking extinct animals found in no other continent, for South America was separated from North America for a long period and developed its own peculiar animals.

Elephant-like animals, called mastodons, recently discovered in southern Arizona, were mired in boggy mud holes adjoining springs. Some of their limb bones are found in erect position and the tops of the skulls are crushed in as though they were trampled on by other animals coming to the water holes. Cave deposits have yielded many interesting fossils. Some of these caves were the homes of beasts of prey and the fossils found there are their own remains and the remains of their victims. Other cave deposits are gashes into which animals fell and into which carcasses and bones of other animals were washed by rains. A crocodile, tapirs, peccaries, an antelope similar to the African eland and other animals that seem out of place in eastern United States were found in a cave near Cumberland, Maryland. Although fossils have been discovered in a few other caves in this country, no systematic attempt has been made here to ex-



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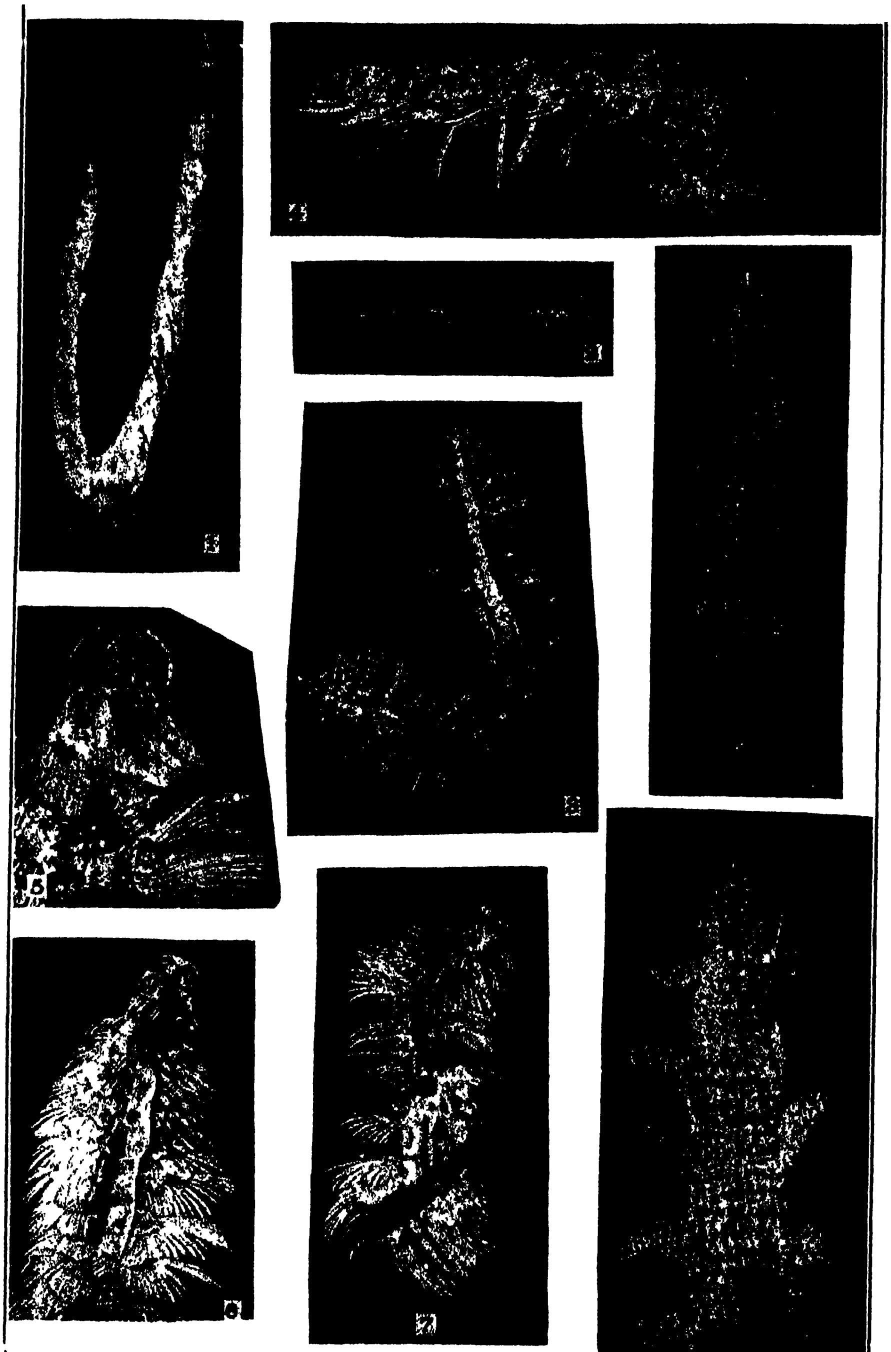
U. S. Geological Survey

FOSSIL PLANTS OF EOCENE AGE FROM TEXAS AND LOUISIANA

CANNA LEAVES.

plore caves for fossil animals. Rancho la Brea, within the city limits of Los Angeles, where asphalt has accumulated from escaping oil, is the most spectacular fossil locality in America. Here animals that lived during the Ice Age were trapped in the sticky asphalt. Animals that were caught served as bait for beasts and birds of prey and they in turn were trapped in great numbers. Water birds were caught along the edge of the pools of water that collected on the asphalt. More than sixty giant ground-sloths, two thousand saber-tooth tigers, three thousand giant wolves, to say nothing of short-faced bears, lions, camels, bisons, peccaries, horses, tapirs, mastodons, mammoths and many other animals and a great variety of birds have already been dug out of the asphalt. Despite the great number of animals trapped, complete skeletons with the bones in place are rare, principally because the bones were separated by movement of the plastic asphalt. At another famous locality in Bavaria fine muds, which now are quarried as lithographic stone, were laid down in lagoons behind reefs. These muds contain many remarkable fossils that lived long before modern animals appeared. Flying reptiles and the earliest known bird—a bird that had teeth and a backbone down its tail—fell in the mud and were covered by wind-blown dust. Impressions of the feathers of the bird are faithfully preserved. Sea animals were brought in alive when the lagoons were flooded and



Smithsonian Institution

MIDDLE CAMBRIAN WORMS FROM BRITISH COLUMBIA

ALTHOUGH THESE FOSSILS ARE MANY MILLIONS OF YEARS OLD, THE DETAILS OF THEIR STRUCTURE ARE FAITHFULLY PRESERVED IN THE FINE MUD IN WHICH THEY WERE BURIED.

signs of the death struggles of some of them can plainly be seen. Here and at many other places impressions of insects are preserved in fine mud, but the most complete fossil insects, as perfect as they were when they died, are found in the resinous gum of pine trees that has hardened to form amber.

Land plants are found in stream, lake, swamp and lagoon deposits. Leaves that fall in mud or sand leave imprints that become fossils if they are buried before they are destroyed. Such imprints are the most common plant fossils. In fine mud all the details are clearly shown. The plant tissue may disappear or it may remain as a film of carbon or as mineral matter that has taken its place. Tree trunks firmly rooted in the soil in which they grew have been uncovered. Wood that was buried and then petrified is common. Some of the most remarkable plant fossils found in America are fungi preserved in petrified wood. A locality in France is famous for leaves, fruits, seeds and flowers that fell in water rich in lime and were incrusted with lime.

When everything is considered it is remarkable that such a great variety of fossils has been dug up. All these remains represent animals and plants that happened to be buried before they completely decayed. Even then they would remain undiscovered unless they were brought to light in some natural or artifical excavation. Every year expeditions uncover and collect new material and the number of these animals and plants, some of which are grotesque beyond belief, is continually being added to.

ARE THE HEAVENS FULL OR ARE THEY VOID? A HISTORY OF HYPOTHESES

By Professor FLORIAN CAJORI
UNIVERSITY OF CALIFORNIA

I. Descartes' Theory of Vortices

Aristotle in his "Physics" and his book on the "Heavens" argued against the existence of a vacuum and filled the universe with a very thin hypothetical medium or plenum. After him, for nearly two thousand years, the universe was usually conceived to be a vast void. Then came the speculations of the great Frenchman, René Descartes. His mechanical hypothesis regarding the causes of the motions of heavenly bodies was advanced in 1644.[1] At that time the Copernican system was a century old. Kepler had established his three laws of planetary motion; Galileo had directed the telescope to the sun and seen sun spots, to the moon and had seen craters, to the planets and seen Saturn's ring "three-fold." A knowledge of *how* the heavenly bodies moved raised the question of *why* they moved. Galileo, in one of his Dialogues, lets Simplicio say, "The cause of this is most manifest; and every one knows that it is gravity." To which Salviati replies: "I do not question you about the name, but the essence of the thing, of which essence you know not a tittle . . ." Descartes' theory supplied a reason why, which captured the uncritical imagination of men of his time. Descartes made the sun the center of a great vortex or whirlpool of subtle transparent matter of interplanetary space, within which were smaller vortices. He compared his vortices with what one sees at a sharp turn of a river; the large vortex at the turn is accompanied by small eddies. The solar vortex carries the planets around, the inner parts of the vortex having a greater angular velocity than the outer, thus accounting for Saturn's thirty-year period of revolution to the earth's one-year period. The planets are the centers of smaller vortices; that of the earth carries the moon around in a little over twenty-seven days. Stars are constituted like the sun; each star is the center of a vortex. These stellar vortices fill all space; they touch each other. To avoid disastrous entanglements, contiguous vortices must rotate in opposite directions as would two rotating cylinders pressing against each other. That it is possible to fill space with such vortices, properly coordinating their movements to each other, Descartes did not show conclusively. His drawings of vortices do not clearly explain the behavior of the vortices in three dimensions.

This theory of vortices offers difficult mechanical problems with which the science of mechanics of that time was unable to cope. Only two of the three laws of motion were understood in 1644. Descartes' universe was constituted of three kinds of matter, the *luminous* matter of the sun and stars, the *transparent* matter of interplanetary space, and the *opaque* matter of the earth and planets. The transparent matter or the carrier of light is composed of globules whose sizes are intermediate between the vor-

[1] René Descartes, "Principia philosophiae," Amsterdam, 1644. See "Oeuvres de Descartes" edited by C. Adam et P. Tannery, Vol. 8, 1904. The translation into French of 1647 is in "Oeuvres," Vol. 9, 1904.

tex matter of the sun and the ponderable matter of the earth. These globules are constantly straining away from the center around which they turn, owing to the centrifugal force of the vortices, so that the globules are pressed in contact with each other. It is the transmission of this pressure which constitutes light. Colors depend upon the speed of rotation of these globules. Vision is due to pressure which we perceive in the same manner as a blind man perceives objects by the pressure these objects exert against his stick.

Descartes' exposition of his theories is very skilful. The arrangement of the subject is orderly; one topic is taken up at a time and made clear by an appeal to intuition and analogy. For example, sun-spots are made clear to every one by comparison with the froth which gathers upon the surface of boiling liquors. We are tempted to believe that Jules Verne, before writing his romances, took lessons in the art of exposition from Descartes. It would seem that Descartes aimed to leave as little as possible for his successors to do, for he worked out his theory of the universe in almost every detail. Thus he explained magnetism by assuming a vortex of fluid matter surrounding each magnet. Descartes' bold mind, following the method of philosophy, could travel immeasurably farther than the modern experimental scientist whose cautiousness and submissiveness border on servility, being willing to take only one or two short steps at a time, for fear that he might otherwise travel in a direction not sanctioned by the imperious decrees of experimental evidence.

II. Struggle between the Systems of Descartes and Newton

What reception was given to Descartes' vortices? Descartes became involved in controversies, but they did not concern his theory of vortices. That theory spread as rapidly as possible at that time. The original edition was written in Latin, which was the universal language of philosophy and theology. But through the efforts of a friend, a French translation, with additions by Descartes himself, appeared in 1647 and appealed to a wider circle of readers. Descartes died three years later (1650). Twenty-one years after his death, Descartes' vortex theory received a popular exposition in the famous text-book on physics, written in French by Rohault. A Swiss physician, Théophile Bonet, made a Latin translation of this text-book, which appeared at Geneva in 1674 and in London in 1682. Thus England began to use this popular text-book five years before the publication of Newton's "Principia." But long before this, Cartesian cosmology had invaded England. Henry More, of Christ's College, Cambridge, one of the first fellows of the Royal Society of London, in his earlier years, had been in correspondence with Descartes and was an admirer and supporter of Descartes. More's friend, Joseph Glanvill, of Exeter College, Oxford, also a fellow of the Royal Society, wrote appreciatively of Descartes' vortices. The writings of Robert Boyle teem with references to Descartes, "the most acute modern philosopher" whose "great wit" he greatly admired. But in Boyle there is only one reference that we could find, to the Cartesian theory of vortices, and that reference was "without allowing this hypothesis to be more than not very improbable."[2] Robert Hooke, of London, wrote in criticism of some features of the vortex theory.[3]

The struggle between Cartesian and Newtonian natural philosophy constitutes an interesting chapter. Descartes' vortices reached their greatest popularity about the time when the validity of

[2] "Works of the Honourable Robert Boyle," Vol. 5, London, 1772, p. 403.

[3] Robert Hooke, "Micrographia," London, 1665, pp. 60, 61.

the hypothesis was being undermined. The Cartesian doctrine had elements of popular strength. The non-mathematician could understand it, but could not understand Newton's system. The law of inverse squares meant nothing to one unaccustomed to mathematical thinking. Thus the Cartesian system enjoyed a tremendous advantage. On the other hand the British mathematicians, Halley, David and James Gregory, Keill, Whiston, Cotes, Taylor, Robert Smith and Saunderson favored Newton's doctrines. Newton himself lectured at Cambridge as late as 1699, but the details relating to his activity as a lecturer are extremely meager. After 1692 he had a long illness. In 1695 he was appointed warden of the mint. He was succeeded in the Lucasian Chair at Cambridge in 1693 by Whiston, who lectured on Newtonian philosophy. From these facts alone one might infer that Newton's system easily displaced Cartesianism in British universities. But such was not the case; the Cartesian system displayed wonderful vitality, even at Cambridge. For about forty years after the publication of Newton's "Principia" the French system maintained a foothold in England. We cite a few facts in support of this statement. The essayist, Joseph Addison, of Magdalen College, Oxford, delivered an oration in 1693, six years after the publication of Newton's "Principia," in which he praises Descartes, "who had bravely asserted the truth" against the followers of Aristotle.[4] Whiston[5] refers to David Gregory's teaching Newton at Edinburgh, "while we at Cambridge, poor wretches, were ignominiously studying the fictitious hypotheses of the Cartesian." We have already referred to the publication in England in 1682 of Rohault's physics, containing a popular exposition of Descartes' system. Fifteen years later, in 1697, a new translation of that book into Latin appeared from the pen of Samuel Clarke, of Caius College, Cambridge, whom Whewell describes as a "friend and disciple of Newton." While the translation was in progress, Whiston expressed himself to Clarke on the fitness of such a translation in the following terms:[6] "Since the youth of the university must have, at present, some System of Natural Philosophy for their studies and exercises; and since the true system of Sir Isaac Newton's was not yet made easy enough for the purpose, it was not improper, for their sakes, yet to translate and use the system of Rohault . . . but that as soon as Sir Isaac Newton's Philosophy came to be better known, that only ought to be taught, and the other dropped." It should be added that Rohault's was reputed to be by far the best treatise of that time on physics in general. Clarke's translation, in better Latinity, played an important rôle as a text-book, both in English and American colleges. John Playfair[7] says that this new and elegant translation contained additional notes, in which Clarke explained the views of Newton, so that the notes contained virtually a refutation of the text, avoiding, however, all appearance of controversy. Thus, continues Playfair, "the Newtonian Philosophy first entered the University of Cambridge, under the protection of the Cartesian." Playfair's statement needs emendation in one respect. Clarke's edition of Rohault, as printed in 1697, did not contain the additions as footnotes, but as annotations at the end of the volume, which are

[4] David Brewster's "Memoirs of Sir Isaac Newton," Vol. 1, 2. Ed., Edinburgh, 1860, pp. 291, 292.

[5] Whiston's "Memoirs of his own life," p. 36, quoted by Brewster, *op. cit.*, Vol. I, p. 291.

[6] Brewster, *op. cit.*, Vol. I, p. 295.

[7] John Playfair, "Dissertation Fourth" in Encyclopaedia Britannica, 8th Ed., Vol. 1, pp. 609, 610; quoted by Brewster, *op. cit.*, Vol. 1, pp. 290, 291.

shorter than in the later editions and refer to ancient writers, and *do not refute* Descartes' theory of vortices. Clarke's refutation came at a later date. Four editions of Clarke's Latin translation appeared. The third, issued in 1710, differs from the first in having the notes, not at the end of the volume, but at the bottom of the page as footnotes and greatly enlarged. This third edition (perhaps also the second of 1703, which we have not seen) contains a new annotation which relates to Descartes' vortices and points out conclusively that these vortices do not explain the facts of observation. They do not explain the motion of comets which cut the orbital planes of the planets at all angles; they would make a planet move fastest when furthest from the sun, while as a matter of fact it moves slowest when in that position.

On this subject, there is given a long quotation from Newton's "Principia." The popularity of Clarke's later editions of Rohault may be due largely to the footnotes. Taken as a whole, the text was acceptable to followers of Newton as well as to followers of Descartes. Both sides were fairly presented. Professor Playfair calls attention to the fact that the tutors in colleges, whose instructions "constitute the real and efficient system" in a British university, sometimes held different views from those of the professors. Thus Professor Keill introduced in his lectures Newtonian philosophy at Oxford, but the Oxford tutors "were not cast in that mold till long afterwards." Ball states that "at Cambridge until recently professors only rarely put themselves into contact with or adapted their lectures for the bulk of the students. . . . Accordingly if we desire to find to whom the spread of a general study of the Newtonian philosophy was immediately due, we must look not to Newton's lectures and writings, but among those proctors, moderators, or college tutors who had accepted his doctrines." Clarke's edition of Rohault suited therefore the needs of tutors, whichever of the two opposing scientific views they favored. That in 1723 Rohault's text was by no means discredited in England is evident from the appearance of an English translation of Clarke's edition, with the notes. Other editions of this appeared as late as 1729 and 1735. According to Hodlay's life of Samuel Clarke, Rohault was still the Cambridge text-book in 1730, three years after the death of Newton and forty-three years after the appearance of Newton's "Principia." It looks as if two different practices of instruction had been carried on for many years without open controversy between the two factions, one favoring Descartes as expounded by Rohault, the other favoring Newton as expounded in Clarke's footnotes, in Whiston's lectures published in 1710 and in the publications of Richard Laughton, a noted tutor at Clare Hall in Cambridge. Desaguliers,[8] who moved from Oxford to London in 1713, informs us that "he found the Newtonian philosophy generally received among persons of all ranks and professions, and even among the ladies by the help of experiments." Somewhat at variance with this is the statement of Voltaire,[9] who visited England in 1727, and declared that though Newton survived the publication of the "Principia" more than forty years, yet at the time of his death he had not above twenty followers in England. But Voltaire[10] said also: "A Frenchman who

[8] Jean T. Desaguliers, "Physico-Mechanical Lectures," London, 1717; quoted by W. Whewell, "History of the Inductive Sciences," Vol. 1, 3 Ed., New York, 1875, p. 426.

[9] F. M. A. Voltaire, quoted by Brewster, *op. cit.*, Vol. 1, p. 290.

[10] F. M. A. Voltaire, "Elemens de la philosophie de Newton," 1738; "Oeuvres," Vol. 31, 1785, quoted by Whewell, *op. cit.*, Vol. I, 1875, p. 431.

arrives in London finds a great alteration in philosophy, as in other things. He left the world full, he finds it empty. At Paris you see the universe composed of vortices of subtle matter, in London we see nothing of the kind."

On the European continent, the vortices of Descartes enjoyed a longer life. Attempts were made by Huygens, Perrault, Johann II Bernoulli and others to remove some of the glaring defects of the original theory of vortices, but by the middle of the eighteenth century the Newtonian system had gained complete ascendancy.

III. The Eighteenth Century

The hold of Descartes' cosmology upon the minds of men in the early part of the eighteenth century is apparent from the fact that Roger Cotes wrote a long preface in the second edition of Newton's "Principia," 1713, in which he argues against Descartes' theory of vortices. The statement frequently made, that it was in this preface that Cotes advanced the theory of "action at a distance," needs qualification. Cotes does not use the phrase "action at a distance," nor does he explicitly advocate the view that celestial spaces are void. He does argue that if a celestial fluid exists it "has no vis inertiae, because it has no resisting force." The implicating sentences of his preface read as follows: "Those who would have the heavens filled with a fluid matter, but suppose it void of any vis inertiae, do indeed in words deny a vacuum, but allow it in fact. For since a fluid matter of that kind can no ways be distinguished from empty space, the dispute is now about names and not the nature of things." Perhaps Cotes avoided an explicit avowal of his belief in empty space, because of Sir Isaac Newton's firm belief in the existence of an ether. Samuel Clarke was more definite. In one of the footnotes to his later editions of Rohault he refers explicitly "to that immense Space which is void of all matter."

While Descartes had aimed to explain all celestial phenomena by one and the same theory, Robert Hooke and Christian Huygens confined their attention to the subject of light, postulated the existence of an ether and set up a wave-theory. Experiments indicated that light travels through a Torricellian vacuum and also through an air pump vacuum. Hence the ether must be present in these vacuums and must penetrate all matter. Newton postulated not only an ether, but also flying corpuscles.

It thus appears that in the seventeenth century, after the publication of Descartes' vortex-theory in 1644, the heavens were not a void but were full of some sort of a medium. At the beginning of the eighteenth century, Descartes' vortices began to be discredited. With the mass of thinkers, the elimination of Descartes' vortices left celestial spaces empty. We have seen that such emptiness was implied in the arguments of Cotes and was definitely asserted by Samuel Clarke. The ether of Hooke, Newton and Huygens was discarded. Individual thinkers of the eighteenth century, as Leonhard Euler, Benjamin Franklin and some others, continued their adherence to a universal ether, but to the great majority of scientists interplanetary spaces were void.

IV. The Nineteenth Century

At the opening of the nineteenth century, Thomas Young in England and Fresnel in France revived the wave-theory of light as offering superior explanations of reflection, refraction and interference phenomena. The wave-theory brought back the luminiferous ether, and the heavens were full once again. This theory was put to a severe

test to explain the polarization of light. Fresnel and also Young were driven to the assumption that light-waves have vibrations transverse to the direction of propagation, and this in turn necessitated an ether that was an elastic solid, for an elastic fluid like air would admit of only longitudinal vibrations. And if this ether is an elastic solid, how can the planets move through it without hindrance? Do the planets slacken in their revolutions? Many centuries of astronomical observation show no trace of such retardation. Fresnel concluded also that the ether possesses greater density in matter than in free space, and this density varies in different directions within a crystal. Part of this dense ether travels with the body, namely, that part that constitutes the excess of its density over the density of the ether in free space, and the remaining part of it is at rest. Fresnel and Young did not succeed in giving a rigorous dynamical theory of the ether.

Attempts at such a theory were made later by Navier, Cauchy, Neumann, MacCullagh, Stokes, Kelvin, Helmholtz, Larmor and others. How can the ether be a solid and yet permit the planets to move freely through it? Stokes and Kelvin pointed out that such substances as pitch and shoemaker's wax, though so rigid as to be capable of elastic vibration, are nevertheless sufficiently plastic to permit other bodies to pass slowly through them. In other words, the ether may behave like an elastic solid for very rapid vibrations, and yet yield like a fluid to the slow progressive motion of a planet. Does the planet carry the ether along with it, or is the ether undisturbed by the motion of the planet, or is there perhaps a partial drift of the ether? This question arises in the explanation of a phenomenon known as Bradley's aberration of light—the annual shifting of the direction, due to the motion of the earth, in which a star is seen. The principle of this shifting is familiar to us in rain falling vertically, which seems, when we run forwards, to be coming into our faces. Bradley himself found an easy explanation of this phenomenon on Newton's corpuscular theory of light, for the corpuscle acted similarly to the raindrop in our illustration. On the wave-theory, this aberration was difficult to explain. Young and Fresnel assumed for this purpose the ether undisturbed by planetary motion, like air quiescent to the motion through it of a swarm of bees. But if ether is not moved in the least by bodies passing through it, how can one explain the interaction between the ether and ordinary matter, as seen in everyday light phenomena? How can a light wave cause molecular motion called heat? In 1845, Stokes[11] replaced this "startling hypothesis" by the assumption that the ether close to the surface of the earth is completely dragged along by the earth, while higher up it is only partially dragged, and "at no great distance, it is at rest in space." On this supposition Stokes endeavors to explain Bradley's aberration and some other phenomena, but he was not altogether successful. An experiment which at the time was interpreted as confirming Stokes' assumption of an ether-drag was made by Fizeau. He sent rays of light in opposite directions through running water and obtained results which seemed to show that the water partially dragged the ether along in its course. More recently this same experiment received a wholly different interpretation by Einstein on his special theory of relativity.

A different movement was initiated by Clerk Maxwell. He was deeply impressed by the ideas of Faraday concerning electric action transmitted through a medium. On the belief in the simplicity of nature, Maxwell assumed

[11] G. G. Stokes, *Philosophical Magazine*, 3d Series, Vol. 27, 1845, pp. 9–15.

that the medium transmitting electric action was the same as the medium which transmitted light. The question arose—What are the properties of a medium transmitting electrodynamic effects?—and he found that such a medium would transmit waves with the velocity of light. Thus arose the electromagnetic theory of light. It was the era in England of model making. Distrusting mathematical symbols that had not a fully defined meaning, there arose a demand for a mechanical model exhibiting the stresses and strains bringing about the actions to be explained. But in recent years, this phase of his work has been pushed into the background. It is not Maxwell's effort along the line of model making, but his differential equations which are now proving to be of fundamental interest. As Jeans recently pointed out, Weyl generalized Einstein's theory of relativity so that it accounts not only for gravitational phenomena but also for electromagnetic phenomena, and arrived at equations which are identical with the electromagnetic equations of Maxwell. It appears that Maxwell's equations are capable of interpretation under various different conditions and therefore possess qualities almost magical. In the words of Goethe's Faust, it has been asked, "War es ein Gott, der diese Zeichen schrieb?" The great correlation which Maxwell's theory established between light and electromagnetism was attractive to many minds, but not to all. Lord Kelvin, for instance, was apathetic to Maxwell's theory. The mechanical properties of Maxwell's ether were not clearly defined; hence Kelvin clung to the elastically solid ether.

V. The Michelson and Morley Experiment

All in all a free ether which was not dragged along by moving bodies was preferred by physicists of that time. Certain phenomena remained unexplained by the free ether, but were not considered necessarily incompatible with it. The equanimity of physicists was rudely disturbed in 1887 when Michelson and Morley, at the Case School of Applied Science at Cleveland, Ohio, performed their famous experiment which, according to the old mode of interpretation, indicated that the earth drags the ether with it completely or almost completely; that is, the ether moves with the earth. The experiment caused consternation among physicists. Glazebrook[12] in 1896 exclaimed, "We are still waiting for a second Newton to give us a theory of the ether which shall include the facts of electricity and magnetism, luminous radiation, and it may be gravitation." Kelvin[13] in 1900 spoke of "two clouds" obscuring "the beauty and clearness of the dynamical theory which asserts light and heat to be two modes of motion." One of the clouds was the unexplained Michelson and Morley experiment.

Of the various suggested paths of escape from this difficulty, the one upon which special attention came to be directed was pointed out independently by G. F. Fitzgerald and H. Lorentz. Both made the assumption that a moving body contracts along the line of its motion. A yard stick is shorter when moving in the direction of its length than when it is at rest. On this assumption the Michelson and Morley experiment could be explained, even though the ether be taken to be stationary, not moving with the earth. The strangeness of this contraction hypothesis was partly removed by an explanation of it on the electric theory of matter. Lorentz went further and, on this hypothesis, deduced mathematically addition theorems for distances and for time, which deviate

[12] R. T. Glazebrook, "James Clerk Maxwell," New York, 1896, p. 221.

[13] Kelvin, *Philosophical Magazine*, 6th Series, Vol. 2, 1901, p. 12.

from Newtonian mechanics and are generally known as the "Lorentz transformations." He made a close approach to the modern theory of relativity. The announcement by Einstein of the special theory of relativity in 1905 and the general theory in 1915 are events in speculative physics which are even more spectacular than the experimental results of Michelson and Morley. Einstein built his theories without the use of the ether. He did not deny the existence of some kind of an ether, but for his immediate needs it was superfluous. In his little book entitled "Side Lights on Relativity," Einstein expresses explicitly his belief in an ether—not the ethers of the nineteenth century, not the ethers of Fresnel, Stokes, Kelvin and Maxwell; those he considers to be gone forever—but an ether which may be made to explain the kinks and twists in the neighborhood of gravitational masses. As yet this new ether of Einstein has not yielded such explanations. It is like Samson shorn of his locks. It is not playing a real rôle in physics. In fact, some devotees of relativity discard ether theories altogether.

V. Is the Special Relativity Theory Doomed?

For several years Einstein's relativity theory remained practically unchallenged by experimental scientists. All observations turned out according to its predictions. Astronomers observed that there was actually a bending of stellar rays of light which pass closely to the sun, just as Einstein had predicted. Relativity explained the peculiarities of the orbit of Mercury which had been mysterious on the old Newtonian mechanics. The shifting to the red of the spectral lines of light from the sun and from other heavy stars was predicted by Einstein and was verified in 1924 by St. John, of Mount Wilson, for sunlight, and in 1925 by W. S. Adams, of Mount Wilson, for light from a heavy star.[14] What was thought might be a crucial experiment between ether theories and the theory of relativity was suggested by Michelson[15] in 1904, and by Silberstein[16] in 1921. It contemplated the study of the effect of the earth's rotation on its axis upon the motion of light. It was actually performed by Michelson and Gale[17] at Clearing, Illinois, in 1925. Two rays of light were sent in opposite directions around a rectangle of water pipe over a mile long, from which the air had been partially exhausted. The two rays on returning to the starting point showed a displacement of a quarter of a wave length of the light used, an amount which can be explained on either of the two theories. If the two rays had matched exactly on returning, the Einstein theory would have been disproved, but not the ether theory. The experiment was not decisive between the two theories. The Fitzgerald contraction did not require consideration here, for the circuit of both rays was essentially the same. It is worthy of note that Michelson's experiment of 1925 indicates that the ether does not appreciably participate in the earth's motion of *rotation* about its axis, while his 1887 experiment indicated that the ether fully or almost fully participates in the earth's annual motion of *translation* around the sun. The two results are not considered necessarily in conflict. Silberstein[18] says: "If there is an almost complete translational (annual) drag of the ether due to its condensation around the planet, there may yet be no appreciable rotational (daily) drag."

[14] *Science*, Vol. 61, May 8, 1925, p. 10.

[15] A. A. Michelson, *Philosophical Magazine*, 6th Series, Vol. 8, 1904, p. 716.

[16] L. Silberstein, *Jour. of Optical Soc. of America*, Vol. 5, 1921, pp. 291–307.

[17] A. A. Michelson and H. G. Gale, *Nature*, Vol. 115, 1925, p. 566.

[18] L. Silberstein, *loc. cit.*, p. 307.

Thus relativity has emerged triumphant from four experimental observations which have been carried on with the greatest skill that instrumental science of the day affords. But we come now to a fifth test, which may be the undoing of Einstein's brilliant generalization. At the Case School of Applied Science and at Mount Wilson, Dayton C. Miller[19] has been making an extended series of experiments with instruments more delicate than those used by Michelson in 1887. According to Miller's announcement made at the meeting of the National Academy of Sciences at Washington on April 28, 1925, and at the Kansas City meeting of the American Association for the Advancement of Science on December 29, 1925, the general result of his observations performed on Mount Wilson gives a motion of the earth relative to the ether of ten kilometers a second, while in a basement at the Case School of Applied Science that motion was less than three and one half kilometers. In other words, the ether was dragged along with the earth to a lesser degree on a mountain top than underground near sea-level. This result is in contradiction with the special theory of relativity. That theory does not postulate the existence of an ether and appears unable to account for the difference in the phenomena of light propagation at low and high levels as exhibited in Miller's experiments. It should be noted that Miller's experiments at the Case School of Applied Science are not in conflict with Michelson and Morley's experiment of 1887, made at the same place. Michelson concluded that the relative motion of earth and ether is probably less than seven and one half kilometers per second, while Miller with more delicate equipment concluded, as already stated, that it was less than three and one half kilometers per second.

However, a bold challenge of Miller's results comes from Eddington,[20] of Cambridge, England. He claims that Miller's results are in conflict with astronomical observations on the positions of stars, extending over centuries, and far more delicate than Miller's experiments can possibly be. Eddington argues that if the ether were dragged along more completely at sea-level than at a mountain top, then this ether would exhibit rotary motion resembling eddies in water that is traversed by a boat and that a ray of light passing through this turbulent ether would be bent in its course. In consequence there would be a difference of as much as seven seconds of arc in the position of a star when sighted at sea-level and when sighted at a mountain top. But no such difference has been observed. It will be interesting to watch the outcome of this conflict. In presenting his argument, Eddington assumes an ether endowed with certain properties. Is it possible that the experimental results are all correct and that it will be only necessary to reconstruct our theories of the ether? Is it possible to reconcile Miller's data with astronomical data by an ether constructed with properties somewhat like those given it by Stokes,[21] Planck, Lorentz or Silberstein?

Very recently a second challenge of Miller's results has come from a physicist, Rudolph Tomaschek, of Heidelberg, who performed two experiments designed to test the ether drift.[22] Both failed to yield evidence for the motion of

[19] Dayton C. Miller, *Science*, Vol. 61, June 19, 1925, pp. 617–621; *Proceedings National Academy of Sciences*, Vol. 11, 1925, pp. 306–314.

[20] A. S. Eddington, *Nature*, Vol. 115, 1925, p. 870.

[21] G. G. Stokes, *Philosophical Magazine*, 3d Series, Vol. 27, 1845, pp. 9–15; L. Silberstein, *Philosophical Magazine*, 6th Series, Vol. 39, 1920, pp. 161–170.

[22] *Annalen der Physik*, 4. S., Vol. 78, p. 743–756.

the earth through the ether. The nature of his two experiments is wholly different from Miller's. He uses condensers. In one experiment Tomaschek employs a charged electric condenser which, if moving through the ether, should produce a magnetic field, but none was observed, even when the test was made on the Jungfrau, one of the highest peaks in the Alps.

VII. The Present an Age of Bewilderment

Are the heavens full or are they void? We answer that we do not yet know. There are those who hold that celestial spaces are filled, not by an ether, but by flying particles of light.[23] The theory of relativity rejects all nineteenth century ethers, and some of its adherents consider celestial spaces void. On the other hand, the theory of relativity itself confronts some ugly facts in D. C. Miller's experiments. But the latter have been declared to be in sharp conflict with well-established astronomical measurements on the positions of stars. Miller's experiments at Cleveland accord fairly well with Michelson and Morley's experiment of 1887 at that same place. But this 1887 experiment, indicating that the ether moves with the earth in its annual path around the sun, is difficult to reconcile with Michelson and Gale's experiment of 1925, indicating that in the rotation of the earth on its axis the ether is not dragged around. Those who discard the ether must discard with it the wave-theory of light which has offered very easy explanations of the optical properties of light, while those who reject the corpuscular theory find it hard to interpret some of the electrical properties of light. Possibly a combination of the two theories will be helpful, as suggested by Sir Joseph Thomson.

Looking backward and passing events in rapid review, we see the heavens as full in the writings of Aristotle. Nearly two thousand years later, they were filled again by Descartes and in a different manner by Hooke, Newton and Huygens. Then they were declared empty by Cotes, Samuel Clarke and most European scientists, only to be filled again, during the nineteenth century, by Young, Fresnel, Faraday, Stokes, Kelvin, Maxwell, Helmholtz and others. Then came the champions of relativity, who either assign the ether a very secondary place in their speculations or discard it entirely. But now they are themselves hard pressed in defense of their famous theory.

What about the various hypotheses? Were they worth while? We answer most positively, *Yes*. They have not led to ultimate general truths, but they have been the means of accumulating a large amount of experimental knowledge which is of value to the material, intellectual and spiritual life of mankind. Scientists have travelled far and seen much. Yet they evidently are on the verge of seeing new sights which equal or surpass anything of the past. They are like the explorers on their first view of the vastness of the Pacific Ocean, who, in the words of Keats,

> Looked at each other with a wild surmise—
> Silent, upon a peak in Darien.

[23] See C. Benedicks, "Space and Time," London, 1924, p. xiv.

THE RELATION BETWEEN CULTIVATED AREA AND POPULATION[1]

By SIR DANIEL HALL, K.C.B., LL.D., F.R.S.

RECENT considerations of the problem of the capacity of the world to continue to feed its growing population appear to have begun with the late Sir William Crookes' address as president of this association when he discussed the ultimate curtailment of the wheat supply through exhaustion of the soil nitrogen. Crookes's views attracted little more than academic attention at the time (1898) because the great tide of wheat that was setting in from the newer countries still in the process of exploitation was barely slackening; moreover, Crookes had neglected a factor then imperfectly appreciated—the fact that land under any of the conservative systems of farming adopted in the old settled countries does not become exhausted. The recuperative effects of the leguminous crops and the assimilation of nitrogen by soil bacteria like azotobacter have maintained unimpaired the fertility of European soils for perhaps thirty centuries of cultivation. Of course, reckless exploitation, such as the continuous growth of wheat and maize without any manuring, will eventually burn out the resources of even the prairie soils of the Middle West, and there is evidence that some of the long cultivated Indian soils are losing fertility if only because dung and other residues which should go back to the soil are being burnt as fuel or sold away; but generally speaking a soil will maintain itself indefinitely at a certain level of production. Latterly in Europe that level has been raised by the introduction of extraneous fertilizers. In his review Crookes predicted the development of the synthetic processes of bringing nitrogen into combination which are to-day rendering that prime element of fertility so abundant and so cheap. But, though we no longer fear the exhaustion of soils, of late years certain sociological considerations have revived interest in the old thesis of Malthus. Over-population and unemployment have become terrible realities in this and other countries; many states are finding themselves under pressure to maintain their standard of living against the intrusion of neighboring races propagating recklessly down to the barest margin of sustenance. Again, various studies of the course of prices of wheat have led to the conclusion that before the war the real price was rising continuously, and that this tendency is manifesting itself again, however much the true sequence of prices has latterly been obscured by fluctuations of currency. These considerations led Mr. Keynes to envisage the approach of scarcity: his attitude is very much a return to Malthus. On the other hand, Sir William Beveridge, addressing the economics section two years ago, dismisses this fear as regards the world at large, whatever may be the troubles in Britain, "the limits of agricultural expansion are indefinitely far." On the whole that seems a very safe proposition; it has been so amply fulfilled for the last hundred and fifty years—during the greatest expansion of population the world has ever known, that it would almost seem to be necessarily true, especially as it can be buttressed by agricultural experiments showing the enormous

[1] Address of the president of the section of agriculture of the British Association for the Advancement of Science, Oxford, August, 1923.

potentialities of production from the soil.

There is, however, one aspect of the case that appears to have received insufficient attention: the capacity of agriculture to provide food for the people depends upon the extent of land available as well as upon the pitch of cultivation—to what degree can the tuning-up of methods be made to compensate for a non-expanding acreage? The first step towards a more exact consideration of the problem may therefore be an estimate of the amount of cultivated land that is required to maintain one unit of population—man, woman and child.

We may make our estimates by either of two methods—abstract or actual. The Food (War) Committee of the Royal Society adopted the figure of 2,618 calories as representing the minimal daily energy requirement of one unit of the population, and calculated that the actual United Kingdom consumption in the five years 1909–1913 amounted to 3,091 calories per head per day. An average English acre of wheat yielding 32 bushels will produce food in the shape of wheat, flour, and pig obtained from the offals, of a calorie value of about 2½ millions. As the average consumption was about 1.13 million calories per head per year, we arrive at the conclusion that one acre of wheat would support more than two head, the relationship being more exactly 0.45 acre to feed one unit of population. But this figure is of no service in our more general consideration. The yield of wheat of 32 bushels per acre is far above that of the wheat-producing areas, and is that of only a few selected countries growing but a limited acreage. It is again the produce of land under the plough, and is consumed in the main as a vegetable product.

The great areas of grassland have a lower output of energy than the cultivated land, and the conversion of vegetable into animal food, whether of natural or cultivated fodder crops, is always attended by a great waste of energy. In the most economic production of pig-meat or milk the energy recovered is only about one sixth of that consumed, and this represents the machine at the top of its efficiency. The longer period of beef production results in a recovery as beef of only one eighteenth of the energy consumed, and in practice the actual wastage of fodder and feeding stuffs doubles or trebles the inevitable losses by conversion. And just as man is not a vegetarian making the most of the mere sustaining power of the land, so he does not use the land for food alone, but also for drink, for wool and fibre and other industrial materials, and for amenities. You may remember Maitland's argument that in the early medieval times of Domesday Book and the two or three centuries following about one third of the arable land of the country was devoted to beer.

We shall not get far on the theoretical basis, and I have only mentioned it as indicating the order of the superior limit of the maintaining power of land.

We must approach the question in a more empirical fashion and endeavor to ascertain the existing relation between the land in use and the people fed by it. Taking again the estimates of the Royal Society's Committee, it concluded that the United Kingdom production of food for the five pre-war years was 42 per cent. of the food consumed. 46.7 million acres of cultivated land then produced 42 per cent. of the food consumed by a mean population of 45.2 millions, which works out to 2.5 acres to each unit of the population. This figure, however, is somewhat misleading in that it does not do justice to British agriculture, since our farming is to a considerable degree concentrated on the more costly elements of diet like meat or milk rather than upon cereals and sugar. For example, 49 per cent. of the food production at home, as against only 24 per cent. of the imported food, consisted of animal products.

Working on a different basis, Sir Thomas Middleton estimated that 100 acres of British land fed forty-five to fifty persons, so that his estimate is over 2 but less than $2\frac{1}{2}$ acres for the maintenance of the unit of population. Middleton proceeds to estimate that 100 acres in Germany fed seventy to seventy-five persons, or 1.3 to 1.5 acres per unit, the advantage being due on the one hand to a much higher proportion of arable land in Germany, and on the other to a dietary in which the energy was obtained more economically, *i.e.*, from potatoes compared with meat, and in meat from pork rather than from beef.

The importance of this relation between cultivated area and population is so great, and the calculations by which it can be ascertained are so approximate and subject to so many estimates of a speculative kind, that I may be allowed to set out various results obtained by different methods.

We may begin by comparing population and area of cultivated land for all European countries except Russia, to which we add the United States, Canada, Argentine, Australia and New Zealand, as the white countries which are also the chief exporters of food to Europe. I exclude all oriental countries because in them the mass of the population possesses a different standard of living, and I have excluded the other South American States and the Union of South Africa and other African colonies because they all possess a very large "native" population and their exports do not bulk large in the food account of Europe. We must recognize, however, that the errors in the calculation will be loaded on to one side, because all the unenumerated countries, Russia and the tropical lands, are to a greater or less degree exporters and not importers of food. Sugar from the East and West Indies, rice and similar Oriental cereals, copra and other edible oils for margarine, are but a few of the agricultural products which the white population consumes from land outside our immediate purview. However, with this proviso we find that in the states enumerated there are 464.1 million hectares of land under cultivation and a population of 481.5 million persons, or 2.4 acres per head.

In the United States about 356 million acres are in cultivation: from this may be deducted as producing exported materials, for cotton 24, for wheat 16, for maize 2, for meat products 22 million acres, or 65 million acres in all. Other products are exported but may be regarded as balanced by imports, so that we find 291 million acres of cultivated land devoted to supplying a population of approximately 112 millions, or 2.6 acres per unit of population.

France we know is a country that is largely self-supporting; it has a population of 39.3 millions and 36.3 million hectares under cultivation. To this acreage we must add 0.9 million for imported wheat, 0.5 for other cereals, and 1.1 for imported meat; the exports of wine and fruit we may regard as balanced off by other imports. The net result is approximately 1 hectare, or 2.4 acres, for each head of the population.

A similar calculation applied to Spain, a country in whose economy neither exports nor imports of food play a large part, gives over 4 cultivated acres per unit of population; but then the so-called "cultivated" land includes a considerable proportion of mountain pasture of a very low order of productivity. On the other hand, Denmark, with the most highly developed agriculture of all countries, shows a production well above the average. A much closer calculation of production is possible for Denmark than for other countries—the data are set out in Mr. Harald Faber's paper before the Statistical Society in 1924. Denmark is a country exporting agricultural produce chiefly in its most costly form as meat, butter and eggs, but the means for equating the export against consumption is supplied in Mr. Faber's paper by the

reduction of production and imports to food units. Making the necessary corrections for imports, it would appear that for the years 1909 to 1913 the population of Denmark was maintained on 63 per cent. of the production of her own land or 1.82 acres per person.

Putting the various estimates together we arrive at the conclusion that under the existing conditions of agriculture among the Western peoples it requires something between 2 and 2½ acres of cultivated land to supply the needs of one unit of population living on the standard of white peoples.

We may confirm this estimate by a consideration of the growth of population during the last century. Between 1800 and 1920 the number of the white peoples increased from about 200 millions to about 700 millions. Data, however, for the land under cultivation in 1920 are very imperfect, and again there was another factor of improved agriculture which came into play in the first half of the nineteenth century. If we take 1870 as our jumping-off point we may estimate the increase in the white man's numbers up to 1920 as approximately 225 millions. During the same period the addition to the cultivated lands in Europe, United States, Canada, Argentine, Australasia, and South Africa, the countries which have provided the white races with food, has amounted to about 450 million acres. Again we reach a relation between cultivated land and population of between 2 and 2½ acres per head.

This brings me to the central point of my argument that an increase of population is in the first instance dependent upon an increase in the area of cultivated land. The expansion of the white peoples in the last century was an event unprecedented in the world's history, and was achieved only because of the vast areas of unoccupied land chiefly in the Americas which suddenly became available for settlement through the power conferred by the railroad, the steamship, and modern weapons. It will be noticed that the population of Europe previously had become comparatively stable even as it has become approximately stabilized in France at present—the expansion came with the opening up of the new lands and in proportion to the amount that could be settled.

Accepting as a basis for further discussion that under the present system of agriculture something more than two acres of new land will have to be brought under cultivation for each unit of increase in the population, we may examine if any means exist of modifying this relationship before considering its consequences.

I have already suggested that a vegetarian diet is the more economical of the resources of the soil, and that meat and all animal products like milk and eggs are produced with an expenditure of energy which may be as low as seven but also as high as twenty times the energy available from them. It is true that to a certain extent the animal will utilize material otherwise of little service to man, like milling offals and low-grade fodder crops—roots, hay, or straw. None the less, if the maximum of population supported by a given area of land is the objective, vegetarianism becomes increasingly necessary, as we see among the crowded populations of India and China. At the same time, the tillage of lands now given up to the grazing of animals becomes possible because of cheapness of labor resulting from a redundant population. Most of the beef and mutton supply comes from land left untilled because of the costliness of labor relative to products; the meat may represent a very low level of production from the land and yet a high cash return for the labor expended. Here the apparent paradox of grazing being general in Middlesex because of the proximity of London. Another item of waste which would have to be eliminated in case of stern necessity is the conversion of potential food into alcoholic drink. Great

Britain ferments the equivalent of one and a half million acres of barley. France devotes 4,000,000 acres, nearly 4½ per cent. of her cultivated area, to vineyards. Without going so far as to say that beer or wine possesses no food value, it is certainly not half of that which could have been grown from the land thus used for the production of drink. In such matters it is vain to prophesy, but I can not help feeling that the race (not individuals) which cuts out meat and alcohol in order to multiply is of the permanent slave type destined to function like worker bees in the ultimate community.

The second question that merits very careful consideration is whether the current agriculture can not be intensified so as to bring about a great increase of production from the existing area of cultivated land. A cursory examination of the average yields of our chief crops in different countries shows what an immense potential increase of production is here open. The average yield of wheat (1921 to 1924) for all the countries of the world collecting statistics was 13.2 bushels per acre; the average yield in Denmark for the same period was 41.4 bushels per acre, more than three times as much. Of course the area devoted to wheat in Denmark is about 200,000 acres in all, or 3 per cent. of her arable land, whereas the wheat acreage of the world amounts to about 250 million acres. The mass production of wheat in the world is from countries of low yield; more than half is grown in countries in which the average yield is less than 13 bushels per acre.

It is from these countries with the low yield per acre that wheat is exported and their production determines the world market, with the consequence that wheat production has been increasing in these and similar countries while it has been shrinking in the European countries with a higher yield per acre.

The dominating factor has been cost of labor; speaking broadly, it may be said that increased yields per acre are associated with higher expenditure per bushel for labor, and the great wheat-producing countries with a low yield per acre are the countries with a correspondingly high yield per man employed. It may be estimated that in England a man's labor produces about 960 bushels of wheat, in Australia 1,500 bushels. A more exact comparison shows that in England the labor cost amounts to 1*s.* per bushel of wheat, against 8*d.* in Canada, this with an average wage rate of 30*s.* to 36*s.* a week in England as compared with 60*s.* in Canada.

1924	Total production million quintals	Quintals per hectare	Bushels per acre
Russia	90	5.4	7.9
Canada	71	8.0	11.4
United States	238	10.8	15.5
India	99	7.8	11.1
Argentina	52	7.2	10.3
Australia	44	10.0	14.3
	594 (mean)	9.09	13.0

Recorded total, 932 (estimated for all countries, 1,250).

All this goes to show that intensification is only to be purchased at the cost of labor and that in the past extending the cultivated area has been a cheaper way of getting the wheat required by the world than by higher farming.

This general statement, however, does not tell the whole story; particularly it disguises the intensification of yield that may be obtained without a commensurate increase of labor. For example, the introduction of more heavily cropping varieties, originated by the skill of the plant breeder, may add greatly to the production from a given area without increasing costs other than those of harvesting and marketing.

One must not, however, expect too much of the plant breeder. Over the

greater part of the cultivated land of the world the gross amount of production is limited by external factors such as water supply, temperature, available fertility of the soil, etc. For example, the plant breeder seems to have had little or no power to increase the absolute production of *Beta vulgaris*; from all the forms of sugar beet or fodder beet (mangolds) on a given soil there is much the same yield of dry matter per acre, though in the well-bred sugar beets the proportion that is in the useful form of sugar is greatly enhanced. The wheats and barleys grown in England had long been subjected to selection and improvement before the scientific methods of plant breeding were evolved, and the further steps in improvement are going to be neither big nor easily won, depending as they do upon altering what Dr. Beaven has called the migration ratio, whereby the plant will convert more of the material obtained from the air into useful grain and leave less as straw. The chief opportunities, in fact, lie in the elimination of susceptibility to disease or destruction by frost, or general tenderness of constitution, by which means the range of the high-yielding cereals or even of cereal growth at all may be enormously extended. Absolute yielding power is perhaps less in question than productive capacity in relation to the environment.

The general enhancement of production by processes which induce improvements of the water supply or the temperature, as by irrigation and drainage, soil amelioration, cultivations, etc., suffer from the disadvantage of calling for labor, until they may prove far more costly than the increased produce can repay. Fertilizers appear to offer more promise. It may be recalled that the general level of production from English land was raised by nearly 50 per cent. between 1840 and 1870. At the beginning of the period the average yield of wheat was of the order of 20 bushels per acre, this being the crop the land was capable of maintaining under a conservative rotation with no extraneous source of fertility. But between 1840 and 1870 artificial fertilizers were introduced and became a generally accepted part of British farming, with the result that the yield of wheat had risen to about 30 bushels per acre, though no other marked change in the routine of cultivation had been adopted during the period. The employment of fertilizers still lags far behind the opportunities of employing them to profit; from 1870 onwards came the great depression upon British agriculture consequent on the growing irruption of the cheaply grown American corn and meat. British agriculture had to shorten sail and restrict expenditure; falling prices breed lack of confidence and even lack of knowledge, for why should a farmer study a science that calls for expenditure when the safer procedure is to let the land grow a small crop without cost rather than to buy a big crop at a dangerous price? At any rate, our employment of fertilizers continues to be unnecessarily low even under later conditions of prices, and the revolution that is being brought about in the production of nitrogenous fertilizers finds our farmers comparatively disinclined to take advantage of it. The various processes of bringing atmospheric nitrogen into combination to which the war gave such a stimulus are now being developed on a vast scale in all civilized countries, and will result in an almost unlimited increase in the amount of nitrogenous fertilizer available at low prices compared with the prices of agricultural produce. Here at least is the opportunity for another step up in production from our cultivated lands comparable with the progress that was made between 1840 and 1870. It is not all plain sailing; the farmer has to study carefully where an increased supply of the cheapened nitrogen can be most suitably applied to his land and what changes in his system of cropping are demanded. The plant-breeders' art is

needed; on most of our land any great enhancement of growth of cereals brought about by the use of nitrogenous fertilizers is attended with the danger of lodging. Few of our cereals possess stiff enough straw to remain standing on a soil enriched to the degree even that is reasonably practicable to-day. Thus the more immediate outlet for the new fertilizers would appear to be the fodder crops which are convertible into meat and milk.

But in the solution of the main problem under discussion—the possibility of intensification of production from the existing farmed land to meet the needs of a growing population—the development of the synthetic nitrogen fertilizers must play a dominant part. Crookes's prophecy is coming true.

I have reserved until the end the question of whether the intensification is necessary or probable. From previous experience it would appear to be probable that as long as new land is available the increase in food supplies will be won less by increased skill and expenditure applied to existing land than by taking in new land. The recent history of United States land affords an illustration; we see little improvement in farming or increase of yield on the older land—we see even abandonment of farms in the eastern states; at the same time we see continued attempts to win new land by forcing into cultivation the arid lands and alkali soils which the earlier settlers had rejected. All over the world it always astonishes the traveller to see on what bad lands the new settler is now trying to farm. Evidently the good easy virgin land is no longer easy to find. It is indeed significant that in the United States vast irrigation schemes are being carried out, though they show little signs of paying interest on their construction; that in Canada new wheats are being acclaimed because they may extend settlement into regions where killing frosts may be expected in August; that "dry farming," with a crop in alternate years only, has to be resorted to in Australia and South Africa. These facts would seem to show that land is getting short in the world, at any rate the naturally productive land or to which the great expansion of the nineteenth century proceeded. Where are we to find the 500 million acres of land such as was added to the world's farm between 1850 and 1900?

In Europe there are still great areas of forest, swamp and heath that might be brought into cultivation, but the process would involve an expenditure both of initial capital and continuing labor out of proportion to the returns. Either the prices to be received for produce must rise greatly or the cultivators must be content with a much lower standard of remuneration before there is much addition to the European area under cultivation. In fact, the present tendency is in the other direction—only Italy, with its great pressure of population increase, is adding to its farming land and reclaiming wastes. All over the poorer land of Great Britain abandoned holdings and crofts may be traced, abandoned for economic reasons alone, because men would no longer live and work so near to the starvation level. Nothing but the direst need or a new scale of prices, whereby agriculture becomes relatively the most paying industry, will ever bring such land back into cultivation. Other European countries to a less degree show the same tendency at work. Russia was one of the granaries of Europe, but over a large proportion of that vast territory production is precarious because of drought on the one hand and cold on the other. It may be doubted whether there will be any great surplus for export even when its agriculture has been fully resumed, so rapid had been the growth of its population to a magnitude which makes the losses of the last decade insignificant.

In the United States there are still great areas of potential farming land; for example, O. C. Baker ("Economic

Geography,'' 1925) estimates a possible increase of the wheat area in the U. S. A. from the present 80,000 to 130,000 square miles. But little of this, however, is the natural easily farmed land the settler looks for; the drift of late years of American farmers to Canada, the efforts to make good the arid lands by dry farming and irrigation, show that the good land has mostly been taken up. What remains is land on which capital outlay is required, land on which production will always be more costly than on the great fertile plains of the Middle West. As in Great Britain, the recent tendency in the United States has been to abandon the cultivation of some of the poorer lands and let them fall back to grazing. Canada still presents enormous potentialities for settlement, though the vast areas the map reveals are severely restricted by increasing aridity towards the west and by cold northwards; Baker considers an increase of the wheat area from 25,000 to 120,000 square miles as physically possible. But similarly on most of this land the wheat will have to be more dearly bought by labor, fertilizers and skill than on the land now being farmed.

The potentialities of South America are less easy of estimate, but in this region there is still a great area of rich plain country unsettled, and it is not too much to expect that another 40 million acres of land are available for farming under present conditions.

The potentialities of non-tropical Africa and of Australia are small; in the latter country the arid zone lies so near to the coast that the additional area available for normal cultivation, is negligible in considering the world's need of food. The great unknown factor in this survey is Western Siberia, a natural wheat area, and Manchuria. All that can be said is that the physical possibilities are great, perhaps as high as 300 million acres, but no one can guess when that will be realizable, dependent as it is upon the establishment of a stable and ordered government. Moreover, on the flank of these regions hang the vast unsatisfied populations of China and Japan, ever ready to expand as the means of sustenance permits, and on this account the expectation of food for the Western peoples from this area can be but small. It is noteworthy that the far Eastern countries, so far from contributing to the food supply of the European peoples, have themselves of late years become competitors for wheat in the world market to an extent that has had a decisive effect upon prices.

As potential sources of food there still remain the tropical countries, in particular Brazil and Central Africa, where abundant rainfalls and high temperatures render feasible a very high level of production from the soil. The last fifty years has witnessed remarkable examples of organized production of tropical crops under western direction and management. The growth of sugar in Java, Cuba, and Hawaii, of rubber in Ceylon and the Straits, of tea in Ceylon and Assam, afford examples of the possibilities of organized agriculture, employing the resources of science, the labor-saving power of machinery, the criticism of cost bookkeeping, such as can rarely be paralleled in the farming proper of the temperate regions. The same organization is being extended to the coconut, which as margarine is becoming one of the chief edible fats of the world. Without doubt the tropics present enormous potentialities of food production for the world, mainly in the direction of oil seeds and edible beans. It must, however, long remain uncertain to what extent the cheap native labor upon which these tropical exploitations are dependent will continue to be available. It does not appear to be possible to maintain a white population itself engaged in the cultivation of the soil in contact with native labor, and Queensland is the only tropical country where agricultural development is being attempted with white labor only. The les-

son of South Africa and to some extent of the southern states of the U. S. A. would seem to be that the white races can not expand agriculturally in competition with the black.

The present annual increment in the white population may be estimated at about five millions. This, taken alone, would necessitate the taking into cultivation of twelve million acres of new land every year. No process of the kind is going on; indeed, for many crops there has been an actual shrinkage in the acreage since the war. Full records are not available, but the following table shows the changes in the areas of some of the main crops:

CHANGES IN AREA UNDER CROP. MILLION HECTARES

	1909–13	1921	1922	1923	1924
Wheat	107.8	103.5	99.5	104.0	105.6
Rye	44.3	37.0	40.7	44.6	43.9
Barley	33.3	29.4	27.3	30.9	30.7
Oats	57.4	55.1	50.7	53.8	55.8
Maize	70.6	71.7	73.0	74.1	(75)
Rice	47.8	53.0	53.3	51.8	52.8
Potatoes	15.3	14.8	15.3	16.2	16.6
Sugar Beet	2.3	1.7	1.7	2.0	2.6
	378.8	366.2	361.5	377.4	383.0

The shrinkage is doubtless no more than a temporary matter, the backwater of the wild fluctuations of prices and values brought about by the war, but it does not promise well for that continued expansion of the cultivated area which the still growing population demands. Indeed, we may detect a new influence at work, the growing disinclination of the civilized peoples to continue in agriculture because of its small and uncertain returns as compared with other occupations. It appears to be a general experience that wherever by the extension of communications the industries or commerce come close to agriculture the latter declines and begins to lose its best brains, its capital, and its men. The lure of the cities is proverbial, but the fundamental factor is economic; unorganized agriculture can not pay the wages obtainable in the organized industries. The decline in the agricultural population of Great Britain and the United States is the most marked, but it is significant that in France, where of all countries the farmer is most protected and prices have been maintained, the peasants are leaving the land for the growing industries, their places being taken, in the south at least, by Italian immigrants.

The flight from the land is manifest equally among the wage-earners of large-scale agriculture and among the peasants or family farmers in whose hands resides the greater part of the cultivation, whether in the old settled countries of Europe or the newer exploitations of America. Again and again it must be urged that the determining cause is economic; for the last half century, save for the abnormal war years, farming has not paid a return on the capital and labor expended comparable with that obtainable elsewhere. It has been said that even the American farmers of the Middle West, who cut prices for all the world, made no profits during the last half-century except those derived from the accretion of land values. And the peasant farmer, who counts neither the capital he has in the business nor the hours of labor he gives to his land, who in Europe is held to the land by secular tradition, finds agriculture unattractive as soon as the growth of industries and the spread of communications render an escape possible. If not the peasant himself, at least the sons look for an easier and less exacting mode of life.

At this stage it would be impossible to begin to diagnose the causes of the comparative unprofitableness of agriculture. Fundamentally it is due to the weakness of the farmer as a commercial unit; the smaller the farmer the more ruthlessly does he compete with his neighbors and reduce prices to a bare level of sustenance for his long hours of labor. Even the large farmers who can put into prac-

tice some of the economies of an ordered industry are helpless against the large commercial organizations which pass on their produce to the customers. Always there is the peasant farmer to cut prices. The position of the imperfectly industrialized farms may be compared with that of the new factories a century ago: their processes are not sufficiently developed to enable them to compete with any certainty of success against the single-handed worker, the power mill has not yet beaten the hand loom.

I can not, however, pursue this issue. I return to my original text, that if we are to continue to feed the growing population of the world on the present methods a continued expansion of the cultivated area is required; new land is called for year after year. I can not see where this new land of the necessary quality is to be found in quantities commensurate with the immediate demand. Doubtless the white races will insist on maintaining their rising standard of living and will apply deliberate checks to their fertility, a process we already see in action. But the restriction of increase will not take effect all at once even under economic pressure, and the danger lies in the period preceding the comparative stabilization. As it can not be supposed that the development of the civilized races can be allowed permanently to be checked by lack of food when food is obtainable, it follows that resort must be had to the intensification of production from the area already under cultivation. The means for that intensification are already in sight, more will be supplied with the advancement of research. Intensification, however, is in the main attended by a higher cost of production, and movement in that direction is likely to be slow until it is stimulated by a rise of prices. Organization will have to be introduced into the industry, and it may be expected that organization will take one or other of three forms. The farmer may be left as the producing unit, but his methods will be strictly controlled and standardized by the great selling corporations that handle his produce, and these corporations may be either commercial ventures or cooperative associations of the farmers themselves. The cooperative venture appears to imply an even more rigid discipline of the individual than that imposed by the capitalist firm. Alternatively the capitalist may venture upon the direct exploitation of large areas of land and industrialize farming as he has industrialized other producing businesses. But capital will only be tempted back to farming, whether for the organization of the business or even to enable the individual to take advantage of the possibilities of intensification, if prices rise to a definitely remunerative level. I hope I have given reasons for supposing that they must rise, because the surge in population set up by the unprecedented extension of the cultivated area last century can not all at once be checked, whereas the new land still available is either inadequate in amount or unsuited to cheap production by the old methods. How close at hand the period of pressure may be it is unsafe to prophesy, but it may be agreed that pressure is sooner or later inevitable and that one of the biggest problems before the world at present is to prevent the pressure developing suddenly or becoming unbearable. The intensification of production is the only remedy, and again the only means of rendering intensification practicable is the continued pursuit of scientific research.

POWER RESOURCES OF THE UNITED STATES

By HARRISON D. PANTON

RALEIGH, N. C.

IN past generations the degree of military power possessed by a nation was the criterion of its greatness. To-day the possession of economic resources and the ability to exploit them has assumed an equal importance in determining a nation's standing as a world influence. The most essential factor in such economic exploitation of natural resources is mechanical power, the substitution of which for human and animal muscle has brought about profound and basic changes in our economic structure during the past century. As a result of considerable propaganda and legislation relating to power development, there is a present and constantly growing interest of the public in our existing power developments, and our potential power resources; the bearing these have on the future expansion of our modern industrialism, and their effect on our national prosperity and standards of living. As is always the case in such a situation much erroneous information has been disseminated, and many fallacious theories have been laid before the public in regard to the matter of our power resources; some of these have secured widespread acceptance, and have served to greatly obscure the true facts. As an example of this kind of thing we may refer to the great mass of misinformation published with regard to the Muscle Shoals development on the Tennessee River.

What, then, are the facts in this important matter, so far as we may determine them in the light of our present knowledge? What deductions as to the future trend of the power situation may we deduce from these facts without indulging in flights of the imagination and unfounded speculation? Let us consider these questions and see if we may not arrive at a reasonably correct visualization of the power situation as it exists in the United States at the present time; the existing trend of this situation, and its probable effect on the future. Every problem consists of certain primary elements with which are associated other elements of secondary importance. In this problem of mechanical power the primary elements are water, coal, technical skill and capital; these are the essentials and will continue to be the essentials. Our four primary elements divide logically into two groups: First, that containing the sources of power, water and coal; second, that containing the means for the application of these sources of energy, technical skill and capital. Without the first group the present day forms of mechanical power could not have been developed; without the second group they would not have been developed. It is the adaption of the inherent energy of the first group by the second to the needs of man that has produced our modern civilization and differentiates it most strikingly from the civilizations of the past.

There are sources of power other than the energy of the flowing stream and the solar energy stored in the vegetation of the carboniferous era which is released to-day when we burn coal. But such sources are secondary sources, which are either approaching exhaustion, as natural gas and petroleum, or have so far defied man's efforts to utilize their energy, as the tides.

Let us first consider our water power resources; the extent to which they have been developed; the amount remaining

undeveloped whose development can be justified on economic grounds; and the relative importance of our water power resources as a whole as compared with our present and future requirements for mechanical power. The total potential water power resources of the United States as given by the Geological Survey, including all sites capable of developing over one hundred horsepower, on the basis of power available 50 per cent. of the time, are fifty-five million horsepower, of which some 20 per cent. has so far been developed. Much of the remaining 80 per cent. consists of sites of such small capacity as to be unsuitable for profitable commercial development and operation in connection with power systems of present-day size; or sites whose remoteness from potential power markets or whose physical characteristics are such as to render their development unprofitable at the present time or in the near future. By far the greater number of our favorably situated water-power sites have been developed or are in process of development. The undeveloped potential water power remaining in the United States, which can be developed at such an investment cost as to produce electric energy more cheaply than it can be produced by steam, does not exceed ten million horsepower.

When we consider that at the present time our total mechanical power requirements, exclusive of that utilized for the propulsion of automobiles and of ships, are approximately fifty million horsepower and that for some years this has been increasing at a rate of 4 per cent. a year, we see that our available water power is capable of caring for only about 40 per cent. of our present requirements, after all available sites which can be profitably developed have been utilized and that the water power actually developed at this time supplies only 20 per cent. of our present requirements. It is greatly to be doubted if the proportion of our power requirements supplied by water power ever exceeds one fourth. From this we see how misleading is the water power propaganda so widely disseminated, declaring that "white coal" is the hope of our economic future, and the cure-all for our economic ills. Water power is to-day and will continue to be an important source of power supply, but it will always supply much less than half of our total mechanical power requirements. The vicious aspect of the present water power propaganda has been its utilization by unscrupulous promoters to induce the investing public to finance water power developments whose development was not justified on economic grounds and which could never be expected to earn a reasonable return on the investment required.

Passing to a consideration of coal as a source of mechanical power, we have shown from the preceding that 80 per cent. of our present power requirements are supplied from coal and that there is a strong probability that at least 75 per cent. of all such requirements in the future will have to be supplied from this source. We have available and known sufficient deposits of good bituminous steam coal to meet our needs for many centuries, assuming that our rate of coal consumption shall continue to increase 4 per cent. a year. However, it is very improbable that such a rate of increase will be maintained; because, with our existing birth-rate and our policy of restricted immigration, our population in the coming decades will show no such rate of increase as it has in the past; because the era of most rapid industrial expansion is undoubtedly behind us, as the productive capacity of our industries is now in excess of our domestic requirements and further expansion is dependent on the development of foreign trade in competition with the other manufacturing nations of the world; finally, be-

cause the substitution of mechanical power for human muscle will show no such rate of increase in the future as it has in the past; automatic machines will continue to be developed, but it is very doubtful if the horse power per workman in industry will show in the future a rate of increase approaching that which has prevailed since 1890.

From the beginning of the use of bituminous coal in this country, a little over a century ago, up to the present time, we have mined less than one per cent. of our known and visible supply of this fuel. Even as a great industrial nation, with an eventual population of two hundred and fifty million, which is considered about the maximum population this country can support without a decline from our present standards of living, we have bituminous coal sufficient to last over one thousand years. In addition we have vast and only partly ascertained deposits of lignites, which are low grade coals and can be burned efficiently by equipment especially designed for this purpose. Including the lignites there remains in the United States a fuel supply sufficient to last for thousands of years. While we should cease to extravagantly waste our coal supplies as has been our practice; there is certainly no danger of their exhaustion for many generations. The alarmists who constantly proclaim that we have sufficient coal for only a generation or two are very grossly misstating the actual facts. It, therefore, does not appear that any great financial expenditures are justified at the present time, having as their object the conservation of coal. The elimination of unnecessary waste would appear sufficient for the present. In the state of Pennsylvania about 12 per cent. of the better grade bituminous deposits have already been consumed; reasonable coal conservation in Pennsylvania is justified, but it is only justified to the point where the cost of the conservation equals the cost of bringing in coal from West Virginia, whose vast deposits of high-grade bituminous coals have been scarcely touched.

We come now to the second group of our primary elements and deal with the means by which the application of the energy inherent in those natural resources treated in our first group to the needs of man is brought about. The first and most important of the members of this group is technical skill, which in its most universal meaning embraces all those products of the human brain that have been developed for the utilization and adaption of the forces in nature to man's service. The United States has always been one of the great leaders in technical skill, and during the past fifteen years very great improvements have been made in this country in apparatus for the production of mechanical power, and the means employed to distribute such power from the point of production to that of consumption. Especially is this true both of water and of steam driven units for the generation of power in the form of electricity.

The hydroelectric generating unit of 1912 had an overall efficiency of around 60 per cent.; that of 1925 is 86 per cent. efficient; that is, the same stream is today capable of producing nearly half as much power again as could be secured from it with the apparatus available thirteen years ago. The improvements made in the efficiencies of steam boilers and of steam turbogenerators are even more marked. In 1913 the best of the large steam-electric generating stations in this country required 16,800 heat units to produce one horsepower-hour of energy, by 1919 this had been reduced to 14,600 heat units and by 1925 to 10,800. As a result of this great improvement in apparatus efficiency, the best plants of 1925 consume 36 per cent. less coal to produce an equivalent amount of power than was required in 1913. The most striking thing about

this improvement in steam-electric generating efficiencies is that over half of it has been made during the past two years, after many had thought such apparatus already developed to its highest economical efficiency, for very little improvement had been made in the thermal efficiency of such apparatus during the seven-year period 1916 to 1922. However, we may expect no future improvements of such magnitude in the efficiencies of power-generating apparatus, as the point has nearly been reached where the increased investment required to secure additional operating efficiency is greater than the value of the saving effected thereby. The present consensus of engineering opinion is that the maximum thermal efficiency which can be achieved in steam-electric stations of large size, without increasing the first cost beyond the economic limit, corresponds to a consumption of nine thousand seven hundred heat units per horsepower-hour of station send-out. To achieve this will require using steam pressures around one thousand two hundred pounds, and steam temperatures in the neighborhood of 800° F; an experimental installation working under these conditions has been made and is proving satisfactory. During the past few years the mercury vapor-steam cycle has been developed to the point where an experimental installation is in service; this installation has proved successful. By the use of this cycle it is believed that thermal efficiencies may be attained corresponding to a consumption of only seven thousand five hundred heat units per horsepower-hour of station sendout. This is an improvement of nearly 25 per cent. increase in efficiency over the best that may be expected from the steam cycle alone. But the development of apparatus for the utilization of the mercury vapor-steam cycle is still in the experimental stage, and it remains to be determined whether such apparatus can be manufactured at a cost where the gain in thermal efficiency will result in a saving sufficient to offset the greater investment required to utilize this combined cycle. Despite the great increase in the efficiency of steam-electric generating apparatus since 1913, the total cost per unit of station sendout is to-day 60 per cent. higher than it was then. It has been the ever-increasing unit cost of such power and the efforts of designing engineers to offset it that have resulted in the great improvement of apparatus during the past several years. The high efficiencies referred to in the preceding have been approached only in the largest and most modern central stations; the average small power plant, either industrial or public service, is still woefully and needlessly inefficient; it has been stated on good authority that it requires eight tons of coal for such small plants to produce the same amount of power that one of the large modern stations can produce from a single ton. It is in the improvement of the efficiencies of these small plants or their entire elimination that there lies the most logical field for efforts having as their object coal conservation. In virtually all such plants considerable improvement can be secured at moderate cost.

The advance in the art of the distribution and transmission of mechanical power in the form of electric current has been very rapid. From its inception in the nineties at voltages around 11,000, it developed very rapidly; until by 1912 there were extensive transmission systems in various parts of the country using voltages as high as 110,000, and transmitting power distances considerably over one hundred miles. To-day voltages as high as 220,000 are used, and power is transmitted over three hundred miles. But it is very doubtful if the voltages used or the distances power is transmitted will increase much above the maximums now in use; for the point in

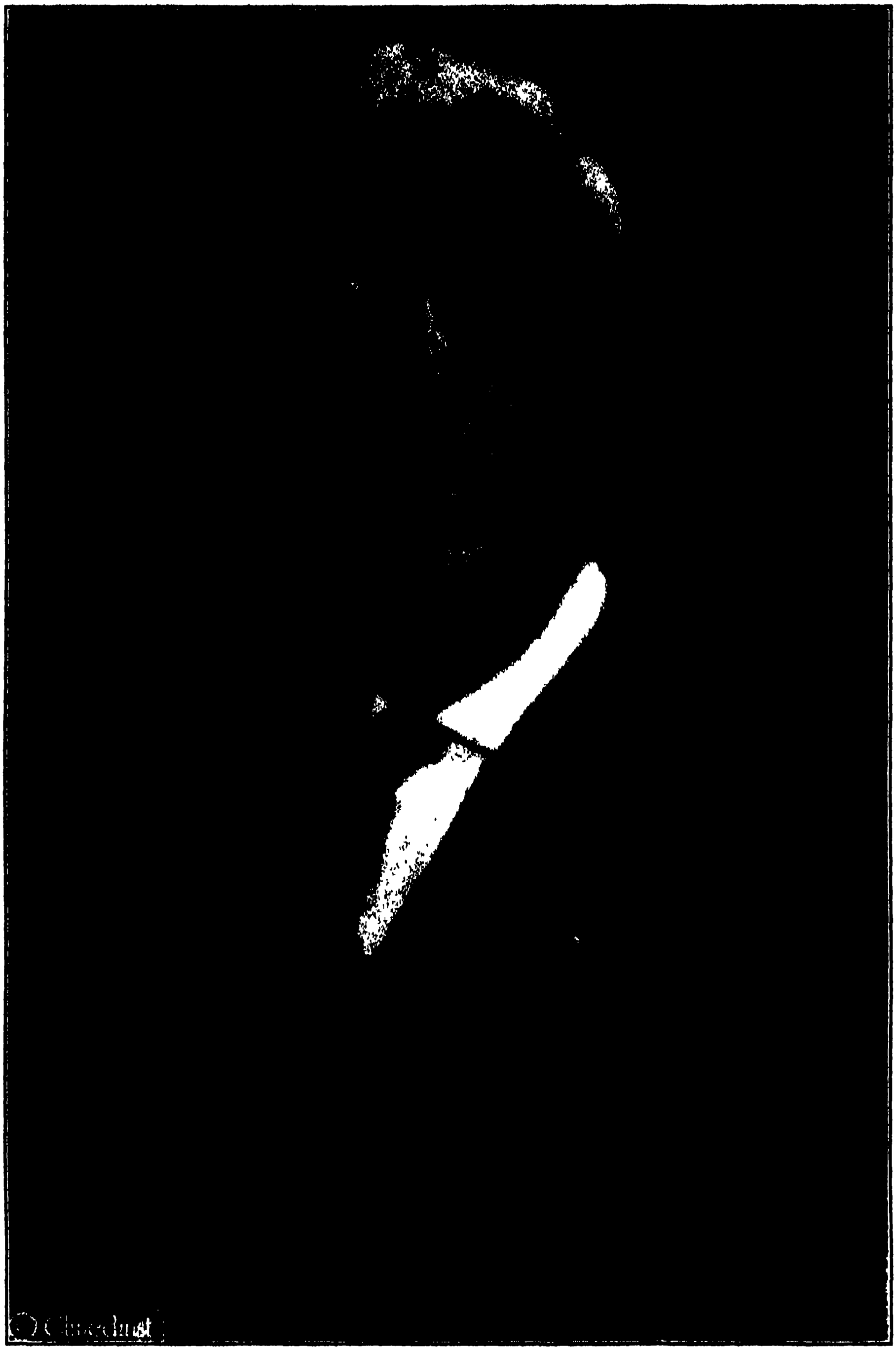
such matters has been reached where certain technical limitations begin to apply, and the cost of overcoming these limitations by the means available through our present knowledge is greater than the gains to be secured by overcoming them. Despite this each year will see the transmission facilities of the country extended through the building of new lines and the interconnection of existing systems, for there is ample opportunity for expansion without the need of exceeding the voltages and distances available for commercial use. The popular belief existing to-day that in a few years the country will be covered with a network of high voltage transmission lines, supplying the entire nation's power requirements with electric power generated by mammoth hydroelectric stations or great steam-electric plants located at the coal mines, is a myth and without foundation in engineering fact. The unromantic reasons why this vision of the future will not materialize are several: First, there are apparently insuperable technical difficulties limiting the distance to which electric energy may be transmitted from the point of generation, the maximum distance to which such transmission will function satisfactorily being about five hundred miles or less; second, that there will be no economic gain in the transmission of power generated by coal beyond the point where the transmission losses equal in monetary value the cost of hauling the coal from the mine to the point of power use; third, that water power sites capable of producing as much as one hundred thousand horsepower are few. Extensive transmission systems exist to-day and many such systems are interconnected, such interconnection being for mutual assistance in time of breakdown or for the exchange of power, either generated or used in the territory adjacent to the point of interconnection. Such interconnections are not for the purpose of through transmission of electric power, and the idea of power being transmitted across the continent by the interconnection of all the intervening power systems is a physical impossibility.

The most comprehensive schemes under discussion to-day having as their objective the conservation of coal are "superpower" and "giant-power." The former has been worked out principally with regard to the requirements of the northeastern industrial section, and the latter with respect to the needs of the state of Pennsylvania alone. While both these plans have many things to commend them, it is doubtful, in view of the great magnitude of our remaining coal deposits, whether there is economic justification for the carrying out of either at any time in the near future. Certain features of both plans which can justify their adoption by their ability to earn a reasonable return on the investment required for their carrying out are worthy of immediate adoption. Other features calling for large investments of capital, and which do not show probabilities of being able to earn a return on such investments should be discarded for the present. In view of what technical skill has accomplished, it is certain that the future will see still further advances by man in his harnessing of natural forces to his service. This would appear to be one of many plausible arguments against the present adoption of conservation measures involving large expenditures of capital; unless such measures are capable of earning a reasonable return on the investment required to make them effective.

We pass now to the consideration of our final primary element, capital. The rôle played by this element in modern power development has been one of ever-increasing importance; this results from the constant increase in the magnitude and scope of the projects undertaken.

Large scale operations, such as characterize present-day power developments, call for great financial resources and the ability to attract capital. As a result all such undertakings are promoted and controlled by powerful financial groups; a small number of such groups completely controlling the present power situation in this country. For the past several years the financial activities in connection with the power industry have centered mainly in the bringing about of extensive consolidations of existing properties; thus bringing under one management the power supply of extensive areas. Such consolidations have been marked by a definite policy of inflated capitalization at figures considerably above the value of the physical property involved. Such a policy, while not inherently vicious, is fraught with considerable risk to the public; as there is always the chance and usually the probability that in the future an effort will be made by the controlling interests to have rates fixed on the basis of the capitalized value of the property, rather than on its actual physical value, this latter being very difficult to determine accurately. The highly successful carrying out of such inflation policies in the past is what has attracted certain financial interests into this field, where the apparent earnings are usually nominal, but the promoters' profits often very large. The results achieved by the regulatory bodies of the various states having under their control the public utilities have not so far been very encouraging; while there are notable exceptions most of these commissions have functioned in a manner unsatisfactory to both the power interests and the public welfare. The great weakness of such regulatory bodies is their ignorance on technical matters, their members as a rule being lawyers or professional politicians, engineer members being the exception, whereas they should be the rule on such commissions. Suitable and just regulation of the power industry by competent state commissions is the only fair and equitable method of dealing with this aspect of the power situation. Power development calls for large amounts of capital and the assumption of great risks by the promoters, and such undertakings should render a fair return to those having the vision and courage to undertake them. On the other hand, in view of the monopolistic nature of the power industry, great care should be taken to see that the public and the small investor are not exploited.

We may summarize the preceding by stating that our water power developments at present furnish only one fifth of our total power requirements and there seems little prospect of this ratio being much increased; that we have sufficient coal and lignites in this country to last for several thousand years, and no coal conservation scheme is justified unless it is able to earn a fair return on the investment required to carry it out exclusive of the conservation feature; that technical skill has made great improvements in recent years in the efficiency of power generating apparatus and there is no ground to believe that the ultimate has yet been attained in this field; that the present financial trend of the power industry is such as to demand sane and just regulation in order to protect both the public and the power companies. It is hoped that the preceding may shed some light for the reader on the existing power situation in the United States and its apparent trend.



DR. JAMES F. NORRIS

PROFESSOR OF ORGANIC CHEMISTRY AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, PRESIDENT OF THE AMERICAN CHEMICAL SOCIETY FOR THE FIFTIETH ANNIVERSARY MEETING HELD LAST MONTH AT PHILADELPHIA.

THE PROGRESS OF SCIENCE

THE FIFTIETH ANNIVERSARY MEETING OF THE AMERICAN CHEMICAL SOCIETY AND THE PROGRESS OF CHEMISTRY IN AMERICA

By Dr. E. E. Slosson
Director of Science Service, Inc., Washington, D. C.

The first impression one got from the meeting of the American Chemical Society held in Philadelphia from September 6 to 11 was that chemistry could be called "the science of short cuts." The word heard most frequently from the lips of the rubber chemists was "accelerators," and all the other chemists talked about the same thing in other words. At the opening session Irénée du Pont said that the use of the new chemical accelerators in the vulcanization of rubber had increased the mileage of tires in the last ten years enough to send 2,500,000 automobiles around the world. Such is the outcome of the accident of the Yankee inventor Goodyear, when he spilled his mess of rubber and sulphur on a hot cookstove and picked it up improved. Another new speeding-up process is the spraying of dissolved guncotton as a substitute for the old-fashioned way of painting with a brush and patiently waiting for it to dry. Mr. du Pont tells of one manufacturer of automobile bodies who by the use of such lacquers has saved five million dollars a year which he would otherwise have had to spend for additional paint shops and drying equipment.

But Mr. du Pont's scientific imagination is not confined to such material things as accelerators and lacquers and dyes. He hopes to reduce or eliminate the time now wasted in sleep. If sleepiness is due to the accumulation of poisonous substances generated by muscular and nervous activity, might these not be more rapidly removed or neutralized by the proper catalytic chemicals than by the slow restorative process of sleep? He also calls upon the chemists to devise drugs that will stimulate the brain without stupefying it; that will exhilarate without subsequent depression; that will make all men supermen; and that will reform the character and improve the disposition by correcting the sourness and crabbedness which as we know are often due to the secretions of disordered glands. "May we not expect," he concludes, "that by injecting proper compounds into an individual we can make his character to order? If study and experiment can reach this result it would seem to be a short cut to the millennium."

Short-cuts likewise formed the main theme of Prince Piero Ginori Conti, senator of the Kingdom of Italy, in his address on "The Development of the Chemical Industry in Italy." He told how the waterfalls of the Italian mountains, formerly esteemed only for scenic value, are now being harnessed to dynamos and employed in making various vegetable products, which used to be prepared by the tedious processes of Nature. Acetic acid, once made by the vinegar plant, is being made by the hydroelectric plant at Villadossola. Wood alcohol, recently renamed methanol, comes now

Photograph taken at Philadelphia. From Wide World Photos

DR. EDGAR FAHS SMITH

PROVOST EMERITUS OF THE UNIVERSITY OF PENNSYLVANIA, AND FOR THIRTY-TWO YEARS PROFESSOR OF CHEMISTRY AT THE UNIVERSITY. THE PHOTOGRAPH SHOWS DR. SMITH RECEIVING THE PRIESTLEY MEDAL AT THE RECENT ANNIVERSARY MEETING OF THE AMERICAN CHEMICAL SOCIETY.

from coal instead of wood. Camphor is made synthetically in Italy instead of extracted from the tree in Japan. Formaldehyde, the familiar disinfectant, is also made artificially. The camphor can be used for the making of celluloid for movie films, and the formaldehyde, added to the casein of milk, gives a similar plastic material. The factory is outstripping the worm in the manufacture of silky fiber, and Italy stands second only to the United States in this industry. Eleven large factories there are now engaged in making synthetic silk and as many more are being erected. Some 13,500 tons of the new textile material were made by Italian factories last year. The Italians are indebted to the bounty of Nature for the hot springs carrying boric acid, but they have made a unique utilization of them in employing their heat for the running of steam engines. One of these volcanic power plants produce 7,500 kilowatts of electric current.

After listening to this story of the surprising achievements of synthetic chemistry in Italy and the United States, it was appropriate that the session should be brought to a close by Paul Sabatier, dean of the faculty of Toulouse University and Member of the French Academy, who told us how the traditional barrier between the animate and inanimate realms was finally demolished by the researches of his renowned teacher, Marcelin Berthelot. Sabatier was the assistant of Berthelot at the Collège de France when he performed the epochmaking experiment of preparing various organic compounds, such as benzene and alcohol, from the primary inorganic elements, carbon, hydrogen and oxygen. The outstanding achievements of Berthelot will be celebrated in France on the centenary of his birthday next year and permanently commemorated by the establishment of a "House of Chemistry" in Paris.

Ice cream made from crude oil was one of the many marvels forecast by Professor James F. Norris, president of the society. Edible fats, the same as those in vegetable and animal foods and other fats equally nutritious but not found in nature can be obtained by breaking up the molecules of mineral oil and rearranging the atoms to form new compounds.

This cracking process has been applied to petroleum for many years to obtain a larger yield of the gasoline distillate, but the investigations recently carried out by the Petroleum Institute have shown that it is possible to attach oxygen to the cracked molecules and so produce alcohols and acids of all sorts. Aromatics, flower perfumes, fruit flavors, drugs and dyes in infinite variety may be made by such methods.

This suggests that petroleum which has hitherto been used for fuel and lubricating may be found in the future to be even more valuable as a source of substances for which man has been dependent upon the chance bounty of nature. Glycerin, which is now obtained from the decomposition of soap fats, can be produced from petroleum, and transformed into nitroglycerin for dynamite. Synthetic plastics like rubber and bakelite may also be manufactured from the same raw material. As one of the speakers remarked, it is unfortunate that we should come to realize the possibilities of petroleum only now, when the Government Oil Commission announces that the known oil reserves of the United States will last only six years at the present rate of consumption.

But Dr. Norris has his answer to that objection, for he foresees the utilization of the limitless stores of energy confined within the atom, as manifest in radium.

"When I saw not long ago in the laboratory of Dr. S. C. Lind a tiny drop of a colorless oil that had been formed from methane—the chief constituent of natu-

STATUE OF DR. EDGAR FAHS SMITH

STANDING ON THE GROUNDS OF THE UNIVERSITY OF PENNSYLVANIA NEAR THE LABORATORY OF CHEMISTRY, WHICH DR. SMITH DIRECTED FOR THIRTY-THREE YEARS. DR. SMITH IS SHOWN STANDING BY THE STATUE. ON THE LEFT IS ITS DONOR, MR. JOHN C. BELL, FORMERLY ATTORNEY-GENERAL OF PENNSYLVANIA AND A TRUSTEE OF THE UNIVERSITY.

ral gas—as a result of the action of this form of energy upon it, I felt a new era in chemistry had dawned," Dr. Norris said. "That droplet meant a supply of combustible liquid to run our automobiles when petroleum is exhausted. We can make methane from carbon and hydrogen when the supply of natural gas fails us. The sun will always be able to convert carbon dioxide into a form from which we can get back carbon."

Dr. G. J. Esselen, speaking in behalf of cellulose in this "Symposium on Future Trends in Industrial Chemistry," demurred to the suggestion of synthetic ice cream and expressed a preference for the old-fashioned method of feeding the cellulose to a cow. But in his own field Dr. Esselen was quite as radical in his prophecies as Dr. Norris. He even went so far as to surmise that the synthesis of cellulose may some day be accomplished in the factory as it is now in the field from the free raw materials of air and water.

Cellulose, which is the woody stuff of trees and other plants, now requires months or years to grow, but if the chemist once learns how to make it he may turn out a purer product in a few days or hours. Already the first steps toward this achievement have been taken. It has been found possible to make glucose artificially by the action of ultra-violet rays on water and carbon dioxide, that is, on "soda-water." It is easy to convert cellulose into glucose, and if we only knew how to reverse this reaction synthetic cellulose would be possible, though whether it would be profitable or not remains to be seen.

Of more immediate interest was the fact, pointed out by Dr. Esselen, that the artificial fibers of cellulose, such as rayon, are being strengthened by new processes and may eventually be made as strong as cotton or stronger. These synthetic fibers are made cheaply from wood pulp and since they have the luster of silk they have within a few years come to be used in twice the quantity of natural silk. But they have hitherto been unable to supplant either silk or cotton because the artificial fibers are weaker and more fragile, especially when wet. If this deficiency can be overcome the synthetic fibers will be a stronger competitor of the natural and this suggests the question whether the slogan "cotton is king" will hold in the future as it has in the past.

Wood pulp is now being obtained from southern hardwoods and no longer exclusively from northern softwoods. Perhaps still faster-growing trees or other plants may be the source of cellulose in the future. Dr. J. G. Lipman, in discussing the possibility of supplanting cotton as the chief textile plant, pointed out that this would effect a revolution in American agriculture, for cotton is a billion dollar crop and the forty-nine million acres now growing it would have to be devoted to other produce.

Dr. Charles H. Herty also prophesied that the rapid expansion of rayon would vitally affect farm and factory. An old and seemingly established industry, varnish, has been revolutionized within the last few years by the rapid spread of the use of dissolved cellulose in lacquers for automobiles and the like.

The most sensational and possibly the most important of the discoveries made public during the week was the announcement before a large audience at the Academy of Music by Dr. Irving Langmuir, of the General Electric Company of Schenectady, of a chemical combination that produces greater heat than any hitherto known.

For over a hundred years the highest heat attainable by combustion was that produced by the burning of hydrogen in an atmosphere of oxygen. But Langmuir has found it possible

THE PRESIDENT AND THE SECRETARY OF THE AMERICAN CHEMICAL SOCIETY

DR. JAMES F. NORRIS, PRESIDENT OF THE SOCIETY FOR THE PHILADELPHIA MEETING, IS ON THE RIGHT. ON THE LEFT IS DR. CHARLES L. PARSONS WHO HAS BEEN SECRETARY FOR THE PAST TWENTY-SIX YEARS.

to get a higher temperature by the unprecedented process of burning hydrogen in an atmosphere of hydrogen. In the oxyhydrogen blowpipe, commonly used for welding or the limelight, two atoms of hydrogen united with one atom of oxygen to form a molecule of water. In the new Langmuir blowpipe two atoms of hydrogen simply unite with each other to form a molecule of hydrogen.

The novelty of the process consists in the possibility of producing a stream of hydrogen gas in the form of single and separate atoms instead of paired atoms, in the form which hydrogen has been hitherto handled. The coupled hydrogen atoms are divorced by passing a stream of the gas through an electric arc. The apparatus is simple, and looks like the ordinary blowpipe that you see used in welding or cutting steel on the street car track. It is held in the hand and the point of the flame directed on the metal while the head of the operator is enclosed in a helmet to protect the eyes and face from the intense light and heat.

A stream of hydrogen from a small copper tube is driven between the tips of the two tungsten electrodes and projects a double flame several inches long. The inner flame consists of atomized hydrogen burning in molecular hydrogen, while surrounding this is a flame of molecular hydrogen burning in air.

A tungsten wire stuck into the tip of the inner flame melts and drops off like an icicle in a gas jet. Now tungsten is a metal so refractory that it required many years of experimentation to find a way of getting it sufficiently softened so that it could be drawn into filaments for electric lamps. Its melting point is over six thousand degrees Fahrenheit, so the temperature of the flame of atomic hydrogen is doubtless more than seven thousand.

If the blowpipe is turned upon the tip of a cone of aluminum, the refractory ingredient of clay and porcelain, this melts down like a tallow candle in a Bunsen burner. If a sheet of steel or other metal is rolled into a tube the seam can be welded without solder by simply running the blowpipe along the joint. When the flame plays on a plate of chrome steel it leaves a string of puddles in its track.

The heat is higher than that of the familiar oxy-acetylene blowpipe though not so high as in the electric arc itself. Dr. Langmuir suggested that we may in time get rid of the rattle of riveting which annoys the neighborhood when a skyscraper is being constructed, and the welded joints of the steel frame would be stronger since no holes need be bored in it.

A further advantage of the new flame is that the metals heated by it are not oxidized, since they are completely enclosed in hydrogen gas. This makes it possible to weld such light metals as aluminum and magnesium, which when heated in air fall into white powder.

Professor H. S. Taylor, of Princeton, supplemented this address by a demonstration of the activity of atomic hydrogen in the cold. He breaks up the pairs of hydrogen atoms by the use of the mercury vapor lamp, familiar to us from its ghastly glow in photographic studios. In this the mercury atoms are "excited," that is, put into a peculiarly active state by the electric current. This activation consists in loosening up an electron, driving it to an outer orbit of the atom, something like what would occur if our solar system should be dislocated by suddenly shifting Venus into the orbit of the earth. When one of these excited mercury atoms comes into collision with a pair of hydrogen atoms it is apt to break their union, and the disrupted atoms of hydrogen seize on the atoms of any other elements at hand and form new compounds. This theory may explain the mystery of what have been called "catalytic action" and the "nascent state."

Synthetic rubber is not a success and a shortage in the supply of natural rubber seems imminent. Such was the consensus of opinion at the raw rubber symposium of the American Chemical Society. Experts from Canada, England, Holland, Germany and Brazil as well as from the leading American rubber companies were in attendance at the session and none of them was able to point out definitely any way of increasing the rubber output of the world until the trees now being planted come into bearing, which will require about seven years.

Dr. H. N. Whitford, of the Rubber Association of America, presented a thorough survey of all known sources and came to the conclusion that the demand for raw rubber will increase at the rate of five per cent. a year for the next five years and the existing plantations could not meet the deficiency, even if the restrictions are removed. If crude rubber rises to sixty or eighty cents a pound this will undoubtedly stimulate the search of South America and Africa for

PROFESSOR RICHARDS AND DR. REMSEN

On the left is Dr. Theodore W. Richards, professor of chemistry and director of the Gibbs Memorial Laboratory of Harvard University. Dr. Ira Remsen has been professor and professor emeritus at the Johns Hopkins University since its opening in 1876 and was president of the university from 1901 to 1913. The photograph was taken at Philadelphia after honorary membership had been awarded to Dr. Remsen and Dr. Richards.

wild rubber, but Dr. Whitford suspects that the number of untapped trees in the forests has been exaggerated and that the maximum output of wild rubber may already have been reached. Higher cost of Para rubber will bring in other rubber-bearing plants, such as the castilloa and guayule, and this with the increased use of reclaimed rubber may prevent famine prices from prevailing in the near future, and enable the poor man to keep his car.

Why rubber trees do not grow under the shadow of the American flag, while they flourish so profitably under the British, Dutch and Brazilian flags, is a mystery that the botanist alone can not solve. It is a question rather for the statesman and financier. There is a native shrub, the guayule, growing wild on the deserts of California and Arizona, which may be made to contribute to our economic independence in this essential commodity. The Carnegie Institution of Washington and the Continental Rubber Company have studied its possibilities as a rubber producer, and the experiments carried on by that company for the last fourteen years were reported in a paper by Dr. W. B. MacCallum. The guayule requires five years to grow and then is only two feet high and weighs a pound dried, but it contains a high percentage of rubber. This is carried in scattered solid particles, not as a milk as in the Brazilian rubber tree, so instead of getting the rubber by tapping, the shrub has to be cut down and ground up and the rubber extracted. Millions of seedlings have been grown and from these ten plants have been selected to provide stock, from which it is hoped to start a plantation capable of giving as good a yield as the rubber trees of Malaya and Sumatra.

How Germany suffered during the war from her deprivation of rubber and the inadequacy of artificial substitutes was first revealed in a paper by Dr. Richard Weil, of the Continental Caoutchouc and Gutta Percha Company of Hanover. Several laboratory methods for making synthetic rubber were known before the war but none of them proved satisfactory on a large scale in this emergency. One process starts from starch, but the potatoes which might have furnished the starch were sorely needed for food. Another process uses coal and lime as the raw materials, combining them to make calcium carbide and from this acetylene gas. By this process 2,350 tons of synthetic rubber were manufactured during the war, but it cost five dollars a pound and was inferior to the natural, except for hard rubber. The automobile tires made from it gave out after about 1,500 miles' service and for inner tubes it would not do at all. Dr. Weil concludes:

"If the use of rubber continues to increase at the same rate, it may be assumed, according to expert opinion, that in a few years there will not be sufficient area under cultivation to satisfy the increasing demand. New plantings would not become productive until 1934. Old plantations will become exhausted, so that it may be expected that the price for raw rubber for the next ten years will be relatively high."

William C. Geer, vice-president of the Goodrich Company, agrees that the artificial product is inferior, inelastic and expensive, "so I am convinced that the world has little to expect, and the planters nothing to fear, from synthetic rubber."

Samples of artificial rubber and of various sorts of rubber substitutes made from rape seed, soy bean and other oils were exhibited to the symposium, but they were regarded more as laboratory curiosities than as serious competitors to the product of the tree.

J. W. Bicknell, of the United States Rubber Company, which has the most extensive plantations in the world, all

DISTINGUISHED FOREIGN CHEMISTS

ON WHOM THE UNIVERSITY OF PENNSYLVANIA CONFERRED HONORARY DEGREES AT THE RECENT MEETING OF THE AMERICAN CHEMICAL SOCIETY. FROM LEFT TO RIGHT THEY ARE SIR JAMES COLQUHOUN IRVINE, PRINCIPAL OF ST. ANDREWS UNIVERSITY; GIONORI CONTI, SENATOR OF ITALY; PROFESSOR PAUL SABATIER, UNIVERSITY OF TOULOUSE, AND PROFESSOR ERNEST COHEN, UNIVERSITY OF UTRECHT.

in foreign territory, explained that the planters could increase their output, as the dairymen had improved their cows, by picking out the best milkers and breeding from them. Records of the yield of individual trees in large numbers for several years showed that half of the trees produced three fourths of the latex and that this characteristic was continuous and hereditary.

Hunting for highly important needles in haystacks of flesh is the kind of thing Gabriel Bertrand, of the Pasteur Institute, Paris, has been doing for many years. He told the medical chemists of his discovery of the apparently great importance of the common metals nickel and cobalt in the human body, though there is not enough of either present in a full-grown man to plate the hands of a wrist-watch. Until he began his researches it was not even suspected that living flesh contained these elements, and he has shown them to be present in almost infinitely small quantity: from one to five parts in ten million is the order of magnitude he found.

But the tiny amounts of nickel and cobalt that we have seem to be absolutely necessary to life, for they somehow act with the insulin produced in the pancreas to prevent the deadly disease diabetes. M. Bertrand found that the pancreas contains much more nickel and

cobalt than do other body tissues, and he found also that when tiny doses of these metals were given to animals suffering from diabetes their recovery was greatly speeded up. He even found that beneficial results followed from doses of nickel and cobalt given to diabetic animals without the use of any insulin at all. These experiments may point the way to improved methods of treating diabetes, especially in the number or size of the somewhat disagreeable insulin injections.

Motion pictures of the minute particles of rubber dancing in the latex tapped from the rubber tree attracted the largest audience of the society on the closing day. This was the first time that such a feat has been accomplished, for the globules of the emulsion are far too small to be seen with the naked eye and the latex looks like cow's milk, a plain white liquid.

But in the micro-movie camera, devised by Dr. Ernst A. Hauser, of Berlin, droplets of caoutchouc suspended in the sap appear as irregular tailed spheres, shaped like commas, and are seen to be in incessant motion, darting hither and thither, colliding and rebounding, so that one would think he were looking through a lens at a drop of water full of animalcules. But they are not living cells and their agitation is due to the jostling they get from the molecules of the liquid, which are kept in motion by the heat: what is called the "Brownian movement" from its discoverer.

In the drop of rubber milk projected on the screen they were stirred up or stopped by a glass filament drawn to a point too fine to be seen, and guided by the hand of Frau Hauser, who has a more delicate touch in such microscopic manipulations than her husband. When she punched a hole in one of the droplets the rubber oozed out through the skin as a viscous liquid. The rubber particles looked as large as baseballs on the screen but really are a ten thousandth to a fifty thousandth of an inch in diameter.

A new method of treating the rubber latex that promises to be of great commercial importance was described by Philip Schidrowitz, the London rubber expert. The customary method is to coagulate the latex with acid which throws it out of solution like curdled milk. Then the mass is mixed with sulfur and other desired ingredients, shaped and heated. The heating combines the raw rubber with the sulfur and makes it solider and less sticky. This process is called "vulcanizing." But Dr. Schidrowitz treats the fresh latex as extracted from the tree directly with sulfur, without previous coagulation. This process of vulcanizing the latex is said to be easier and quicker and the finished rubber is stronger, more durable and more uniform.

Fields of gorgeous dahlias may replace the soberer beets as the mainstay sugar crop of this crop of this country, and the sugar made from their tuberous roots will be half again as sweet as the variety now on the market. W. C. Arsem told of the intention of the interests with which he is associated to start growing dahlias on a large scale for the purpose of manufacturing this super-sweet sugar, known as levulose. The dahlia roots do not contain any levulose, but they are largely made up of inulin, a starch-like stuff that can be turned into levulose by treatment with weak acid. The process outlined by Mr. Arsem sounded almost as economical as the packing-house procedure which makes use of all the pig except his squeal. After yielding its main burden of sugar the left-over sap is to be fermented for commercial alcohol for automobile fuel, and the small amount of pulp in the roots will be worked up into paper or building material.

Another of the dreams of the ancient alchemist, besides the transmutation of metals, seems likely to be realized, for the discovery reported by J. O. Ralls reminds one of the love philter, which has figured so frequently in tale and drama. It has been learned that the characteristically feminine reactions, both physiological and emotional, are influenced by a substance produced in the female sex glands, and that extracts containing this chemical compound can induce normal sexual behavior in female rats that have been rendered sexless by a surgical operation. Dr. Ralls and his associates have succeeded in obtaining extracts of high purity and great power, and hope eventually to solve the riddle of the exact composition of the sex hormone.

Crude codliver oil makes happy hens. This may make many of us, with unhappy childhood memories still sticking to our palates, more sure than ever that hens have no sense. Yet Dr. A. D. Holmes, in a series of experiments on the hatchability of eggs and the livability of chicks mothered by hens on a diet containing codliver oil, showed conclusively that within limits the more they got of the nasty stuff the more and better eggs they laid, and the more and healthier were the chicks hatched from them. This was due, he said, to the high vitamin content of the oil. Moreover, when subjected to the crucial test at the table, neither eggs nor chickens were tainted with any noticeable flavor.

To prevent goiter, swallow sea-weed. This is not the medieval prescription of a "herb wizard," but the ultra-modern advice of J. W. Turrentine, government expert on the chemistry of the hundred-foot-long kelps of Pacific coast waters. It is based on the fact that these sea-plants are rich in iodin, shown by recent medical research to be necessary for the prevention of the disfiguring neck disease. Dr. Turrentine states that because the iodin of sea-weed is held in a nearly indigestible gelatin-like substance, it is released into the system very slowly to do its beneficial work, whereas the easily soluble iodin salts commonly employed are quickly eliminated from the circulation, though they may work mischief by causing skin eruptions before they do so. Dried kelp ground up into flour is the form in which this marine vegetable iodin is to be administered. One can get kelp-flour tablets if he wants to take his medicine straight, or he can get kelp-flour candy or biscuits if he wants to take it under a pleasant camouflage.

This having been the fiftieth anniversary of the founding of the American Chemical Society, a program of unusual scope and character had been prepared. There were 392 papers listed for the meeting, each presenting some new contribution to the science, and it was necessary to hold sessions of several sections simultaneously to get them read. Considering in addition the attractions of the Sesqui-Centennial and the hospitality of the Philadelphians, the chemists needed injections of the proposed anti-sleep potion to carry them through the week.

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OUR GIANT MOTHS

By Dr. AUSTIN H. CLARK
SMITHSONIAN INSTITUTION

ELEGANT in form and beautiful in color, few living things are more attractive than the giant moths. While very few of them are ever harmful to us many are very useful, for from their cocoons come the so-called "wild-silks" of eastern and southern Asia and the East Indies.

Of the moths yielding the "wild silks" the most important are the Chinese and the Indian tussur moths, the moonga and the mezankoorie moths of Assam, and the Yama-mai moth of Japan, all of which are allied to our polyphemus (Fig. 7); the eria or arrindi moth of Bengal and Assam and the cynthia of China (Fig. 6), allied to our promethea (Figures 11, 12) and cecropia (Fig. 1); and the great atlas moth of southeastern Asia with the greatest

FIG. 1.—THE CECROPIA, FEMALE.

FIG. 2.—COCOON OF THE CECROPIA.
FIG. 3.—COCOON OF THE CECROPIA, CUT IN HALF.

spread of wing of any moth, up to eleven and three quarters inches. Several other kinds are also of more or less importance.

Some of these great moths in the countries where they live are more or less domesticated, and extensive efforts have been made further to develop them as a source of silk in Asia, in Europe and in North America. But in spite of this the so-called silk-worm moth, the only truly domesticated insect, which belongs to quite a different group, still holds first place as the world's silk producer, as it did more than forty-five hundred years ago.

We are so fortunate as to have quite a

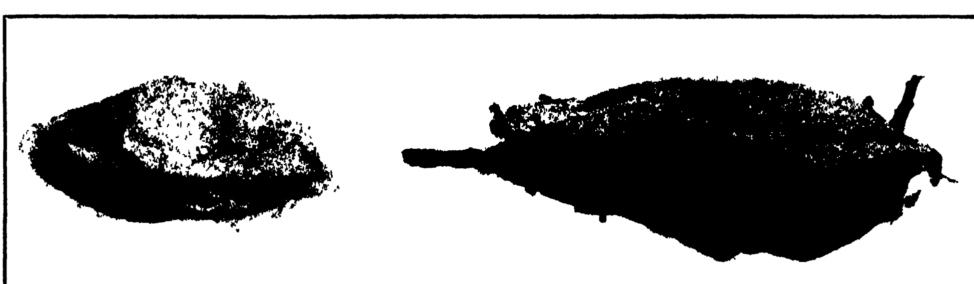

FIG. 4.—A VERY SMALL CECROPIA COCOON, FROM WHICH A PERFECT ADULT EMERGED.
FIG. 5.—A CECROPIA COCOON TORN OPEN BY A WOODPECKER.

fair number of these giant moths. From late spring up to mid-summer, occasionally also in the autumn, you sometimes come across them. You notice them most frequently flying about electric lights or perhaps seated on the light pole or on an adjacent tree or fence. Sometimes they flutter at your windows, or you see the males at dusk flying swiftly by with a strong erratic dodging flight or the females flying by in almost a straight line with little deviation. Two of ours fly by day.

often meet with them. But you often find their remains upon the sidewalk near electric lights, or come upon them while walking in the woods.

All our largest native moths belong to a single group known as the saturnians. There are very many moths belonging to this group, most of them found only in the tropics. All of them are large, and some are very large, almost a foot across the wings. The largest live in southern and southeastern Asia and thence southward to Australia.

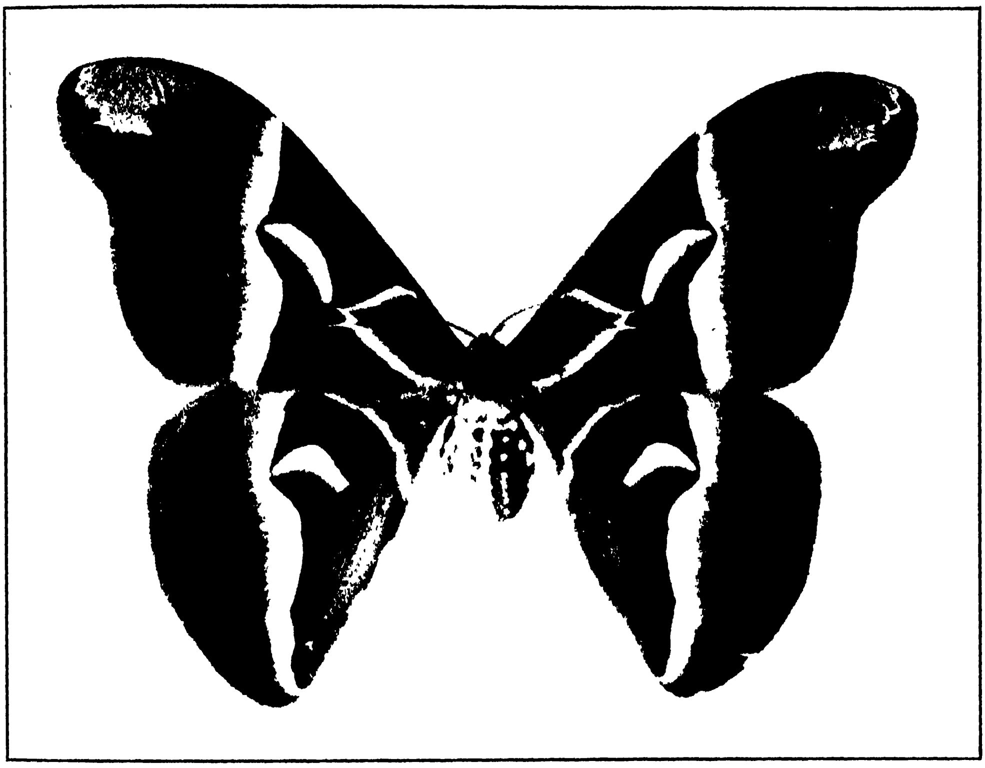

FIG. 6. THE CYNTHIA, FEMALE.

Most of these great moths are really very much more common than they seem to be. Nearly all of them fly only after dark, and mostly high above the ground. Though they sometimes come to lights, as a rule they do not pay much attention to them. In the daytime they remain quietly sitting in the trees, usually high among the branches, so that you do not

A very interesting thing about the moths belonging to this group is that they feed only as caterpillars. In the moths themselves the mouth parts are much reduced, and sometimes almost completely absent. After emerging from the chrysalis these moths can not eat at all, but must live entirely on the surplus food material stored up within their bodies.

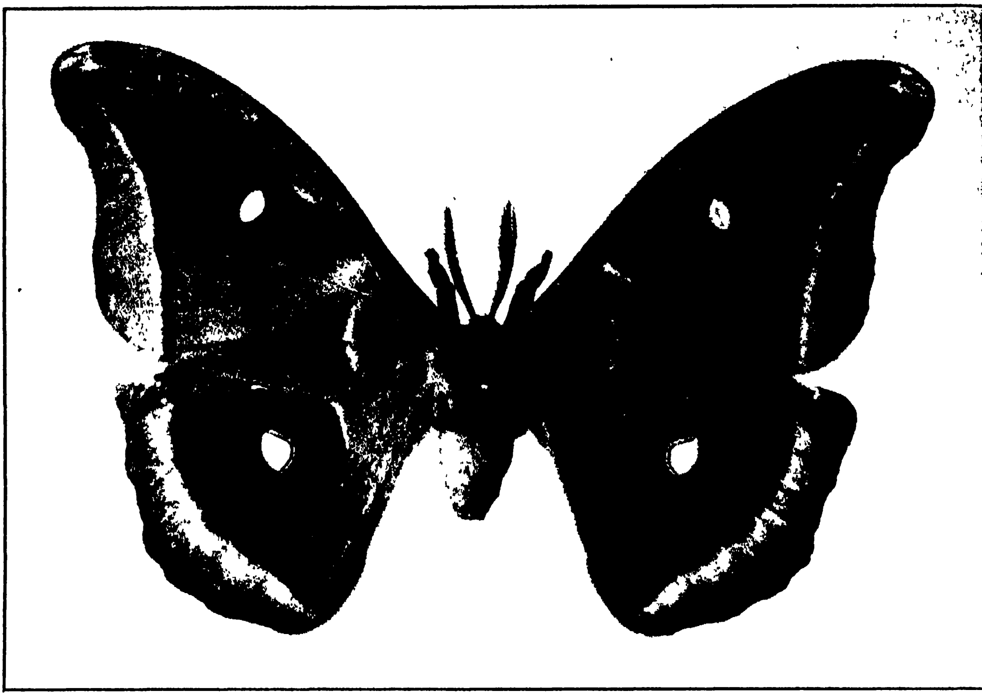

FIG. 7. THE POLYPHEMUS, MALE.

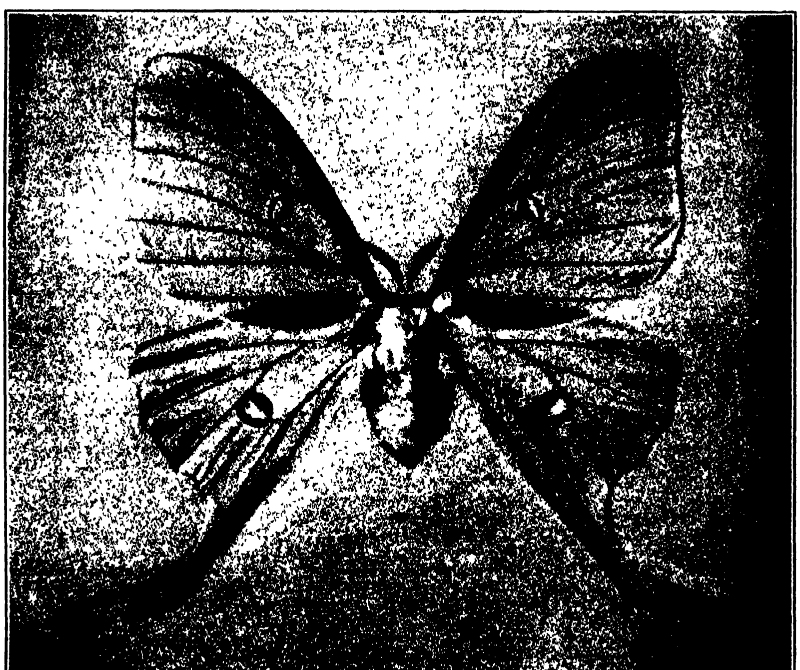

FIG. 8.—THE LUNA, FEMALE.

In the late summer you occasionally find enormous caterpillars, light green in color and very stout, which lack the conspicuous tail seen in the tomato and tobacco worms. These are the young of our giant moths.

With us all these great moths spend the winter in the pupa stage. Most of them construct a silk cocoon which is tough and thick enough to protect them from the elements. Some fasten their cocoons securely to the twigs of trees so that the wind can not tear them loose, while others spin their cocoons in such a way that they are attached only to the leaves and with them fall to the ground in autumn. You sometimes see these lying on the sidewalks when the leaves are falling. The caterpillars of a few of these large moths burrow in the ground and form the pupa there.

The largest of our native moths, and a very common one, is the cecropia (*Samia cecropia*). This moth (Fig. 1), which measures up to seven and one half inches across its extended wings, is of a generally grayish color more or less shaded with red. The margin of the wings is earthy gray. Their outer third is marked by a narrow line of white outwardly bordered with a broader line of red. Each wing bears in the center a large crescentic spot of white and red outlined in black. The body is bright

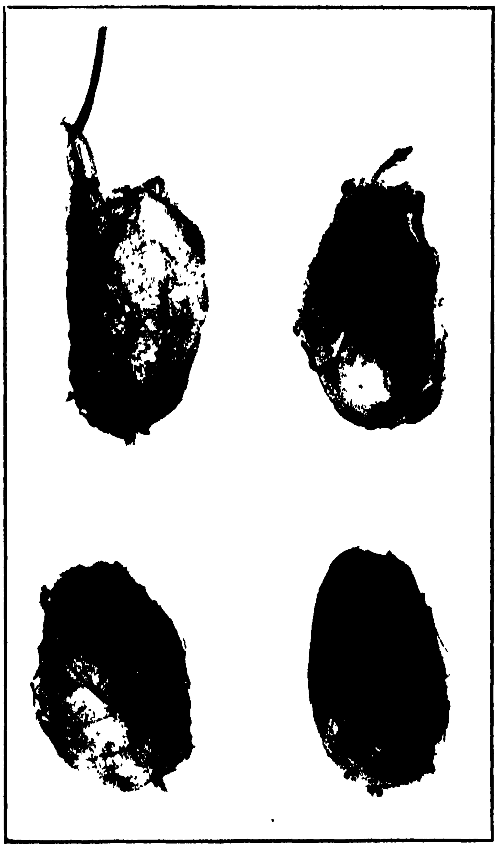

FIG. 9.- A COCOON OF THE POLYPHEMUS, WITH AN ATTACHMENT TO THE BRANCH; ON THE RIGHT THE COCOON IS SHOWN CUT IN HALVES.
FIG. 10.—COCOONS OF THE LUNA.

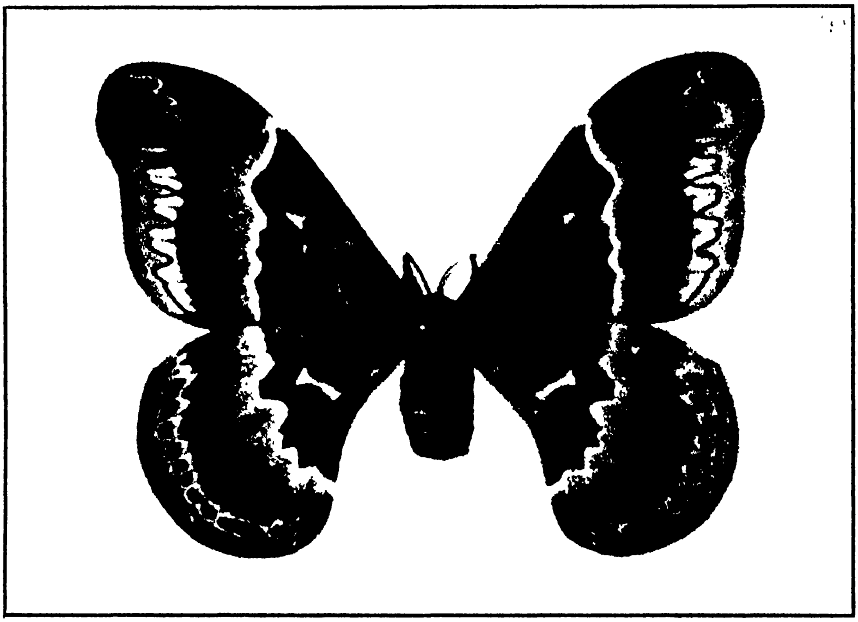

FIG. 11.—THE PROMETHEA, FEMALE.

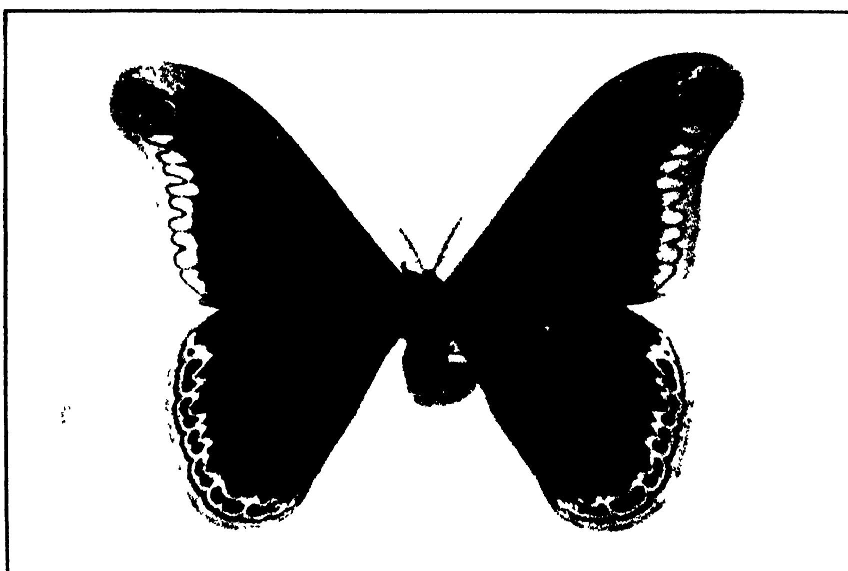

FIG. 12.—THE PROMETHEA, MALE.

red with a white collar and white stripes across the abdomen. The feelers or antennæ are beautifully feathery, very much broader in the males than in the females.

This moth flies from late in May to the middle of July, and is often seen about electric lights. The large green caterpillar feeds on many kinds of trees and shrubs. The cocoon (Figures 2-4) is attached firmly to a twig along its longest side. It varies very much in size. I have raised a perfect, though small, moth from a cocoon which was only an inch and three quarters long; on the other hand the cocoons may be more than four inches long and much inflated. These large cocoons are usually constructed near the ground. The silk when fresh is reddish, sometimes fairly dark and sometimes nearly white; it fades to dull gray in winter. When constructing the cocoon the caterpillar draws down to it several leaves by which it is concealed. These fall away in winter so that then the cocoons become conspicuous.

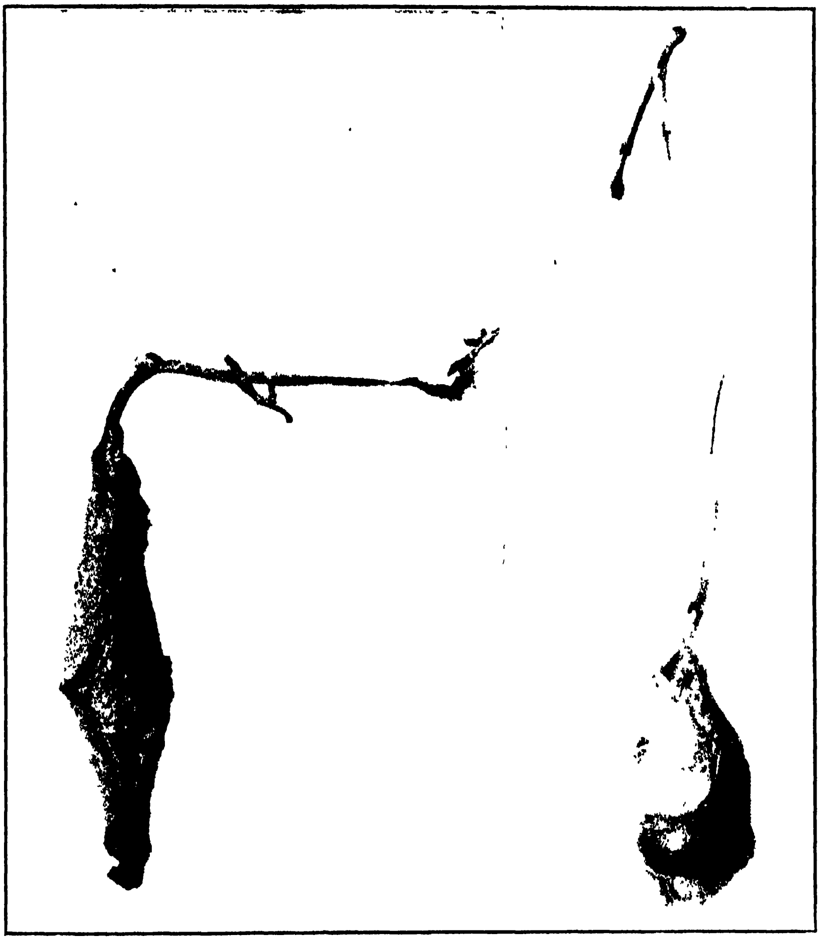

FIG. 13. COCOONS OF THE PROMETHEA.

The woodpeckers in the winter destroy great numbers of them, tearing a hole in them and through this hole eating out the inside of the pupa (Fig. 5). Squirrels also eat them.

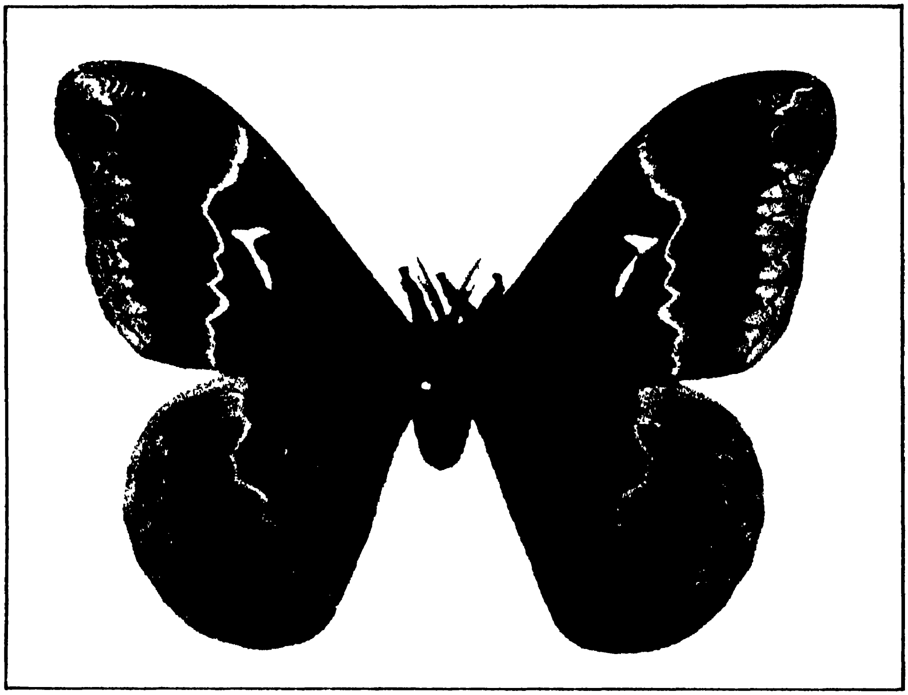

FIG. 14.—THE ANGULIFERA, MALE.

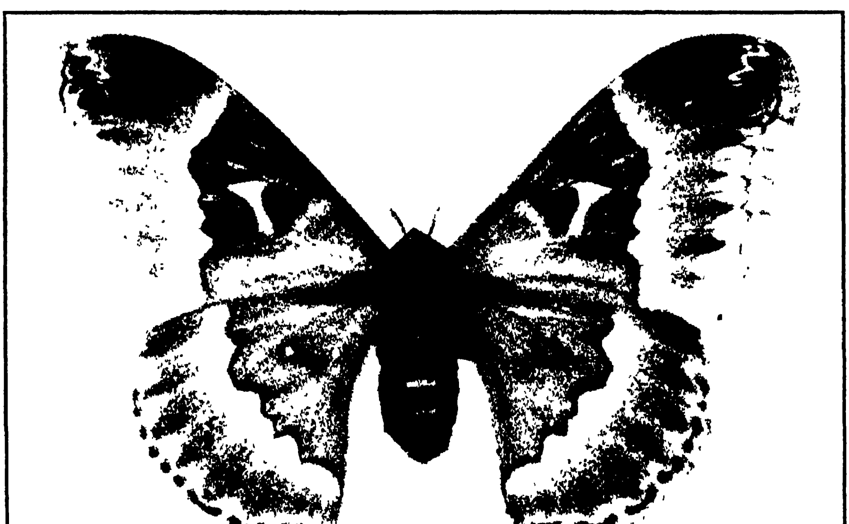

FIG. 15.—THE ANGULIFERA, FEMALE.

In the vicinity of Washington, Philadelphia, New York and Boston there lives a handsome moth known as the cynthia (*Philosamia cynthia*). This moth (Fig. 6) is much like the cecropia in its markings, but it is olive green in color, fading to dull yellow, and its wings are narrower. In Washington it is common in late May and June, and again in the first week of August; there is a third brood in October; but at this time the moth is much less common than in the spring and summer broods. Of 250 cocoons taken from a tree in Washington last October, 50 had recently hatched and some of the moths were still about. This would indicate that of this brood about one fifth of the moths hatch in the autumn while four fifths sleep till spring. Many, indeed, sleep on until the middle of the summer when the children of their brothers and sisters are on the wing. The eggs laid by the moths that fly in autumn are all killed by the winter's cold.

This moth often flies by day in the brightest sunlight, when you are likely to mistake it for a great greenish yellow butterfly.

The caterpillar feeds almost exclusively on *Ailanthus* trees. The cocoon is small for such a large moth, and is constructed within a leaflet of the food plant which is wrapped about it; from the cocoon a heavy band of silk runs up the stem of the leaflet and along the midrib of the compound leaf to the twig to which it is attached. Often two or more leaflets are involved in the formation of one cocoon. Sometimes several cocoons will have a common stem, or two or even three cocoons may be spun together in a mass in such a way that the escape of only one of the moths is possible.

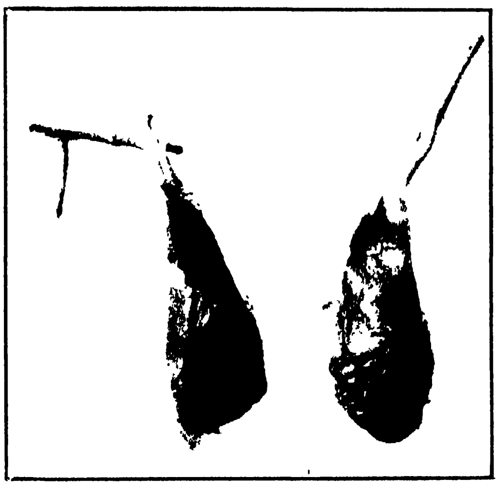

FIG. 16.—COCOONS OF THE ANGULIFERA.

This moth was introduced from China as a silk-worm moth in 1861.

Commoner than the cecropia and nearly as large, though much more variable in size, is the polyphemus (*Telea polyphemus*). In color the polyphemus (Fig. 7) is usually tawny yellow with a large black and blue spot in the middle of each hind wing. There is a transparent spot on the fore wing and another in the outer part of the black and blue spot on the hind wing. Sometimes the wings are reddish, and they may vary all the way from cream color to olive or blackish brown; but dull yellowish is the usual shade.

In the north this moth appears only from late in May to the middle of July, but in the south there is another brood in the late summer. About Washington it is seen commonly in late May and June, but only seldom in the autumn.

The caterpillar, which is a bright translucent green with a brown head, is short and chunky. It feeds on very many kinds of trees. Fifty-six days after hatching from the egg one of these caterpillars had increased to four thousand one hundred and forty times its original weight; during this time it had consumed eighty-six thousand times its original weight in food.

The cocoon (Fig. 9) is ovoid, very tough and dense, and is spun usually between two leaves, falling to the ground with them. Rarely the caterpillar runs a thin band of silk up the stems of one or both of the leaves and thus fastens the cocoon more or less securely to the branch.

The most beautiful of all of our large moths is the lovely light green long-tailed luna (*Tropæa luna*). This is a common moth (Fig. 8) but is less often seen than the cecropia or the polyphemus, as it prefers woods to the more open country and does not fly so early in the evening. It usually first appears long after dark and flies till morning, while the others appear at sundown and fly but little in the darkest hours.

The male luna has a much less erratic flight than the males of the other giant moths. Instead of swooping and darting this way and that, as is their habit, it is fond of dancing up and down for several feet about the outer branches of a tree, something like a ghost-moth.

The luna appears abundantly from May to July, and again in much smaller numbers in late August and September.

The caterpillar is very much like the caterpillar of the polyphemus, but the head is green instead of brown and each division of the body has a fine white line around the sides and back. It feeds on many different kinds of trees. The cocoon (Fig. 10) is like that of the polyphemus, but is very thin and papery. It falls to the ground in the same way.

The commonest of all our larger moths is the promethea (*Callosamia promethea*). This is not so large as those just mentioned. The female (Fig. 11) looks like a small dull reddish cecropia, but the male (Fig. 12) is black with a putty colored border to the wings.

This moth appears in late May or early June, usually later than the cecropia or polyphemus, and flies till August. A few are seen in the late summer. The black male flies only in the daytime, with a very irregular swooping and darting flight. It is commonly mistaken for a large black butterfly. The female flies only at night with a direct and heavy flight.

The caterpillar looks like a small cecropia caterpillar. It feeds especially on wild cherry, tulip tree, sassafras and spice-bush, but also on other trees. The cocoon (Fig. 13) is twice as long as broad and is constructed within a leaf which is wrapped about it. A thick band of silk runs up the leaf stem and is fastened to the twig, and sometimes the twig is in the same way fastened to the branch. After the falling of the leaves these cocoons are very easily seen as they dangle from the branches. They are quite common along roadsides and in the more open woods.

Very much like the promethea but larger and much less common is the angulifera (*Callosamia angulifera*). In this moth the males (Fig. 14) are dark brown instead of black with a prominent white angular spot in the middle of the fore wings. The females (Fig. 15) are much lighter and more yellowish than the females of the promethea, with a large angular white spot in the middle of all the wings.

Whereas in the promethea the males are day fliers and the females fly at

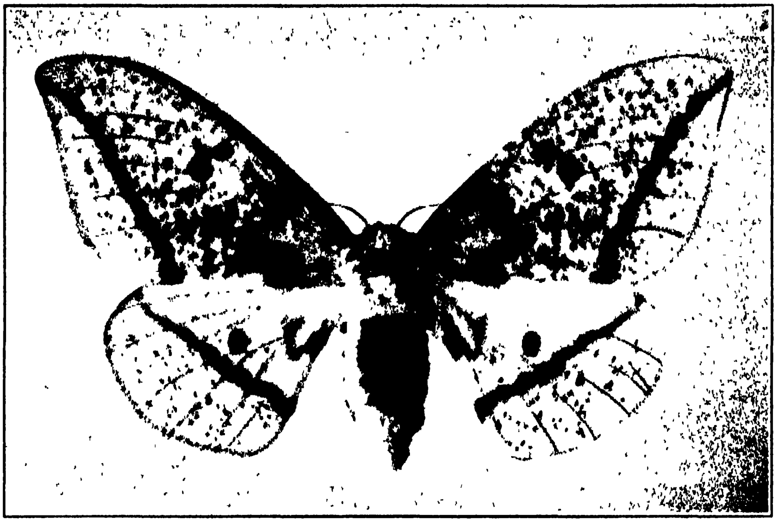

FIG. 17. THE IMPERIAL MOTH.

night, in the angulifera both sexes are night fliers.

The caterpillar of this moth sometimes makes a cocoon like that of the promethea (Fig. 16), but usually it is not fastened to the twig so that it falls in autumn with the leaves.

In addition to these moths we have three others of a different, though related, group which are remarkable for their large size. Of these the caterpillars do not make cocoons but burrow in the ground and transform to pupæ there

The largest, as well as the commonest, of these moths is the imperial moth (*Eacles imperialis*) (Fig. 17). This measures about the same as the cecropia across the wings, but the wings are narrower. Its color is bright lemon yellow with dull rose markings which are much more extensive in the males than in the females. It flies only in June. The caterpillar, which varies from green to brown or nearly black and is sometimes spotted, feeds on many kinds of trees, including pines.

Another moth, not quite so large, is the royal walnut moth (*Citheronia regalis*) (Fig. 18). In this the fore wings are grayish olive or purplish with red veins and a few oval yellow spots, and the hind wings are dull orange. It is found in June. The caterpillar is called the "hickory horn devil" and commonly lives on hickory and walnut trees, but also on many other kinds of trees as well.

The pine devil moth (*Citheronia sepulchralis*) is similar in form, but is smaller and dull brown in color. It flies in June and is rather rare. The caterpillar feeds on pines.

Besides these native giant moths there are two others of a very different type spreading about five inches which sometimes stray here. In these the feelers or antennæ are very long and thread-like. Both are abundant in the tropics of America, whence they are sometimes blown far northward.

The commoner of these, called *Erebus odora* (Fig. 19), is brown in color with a more or less marked scalloped line of white across the wings and a dark eye spot near the front border of the fore wings. It lives normally as far north as southern Florida and the warmer portions of the Gulf states, but occasionally is blown far northward, even reaching Canada.

In the tropics it is extremely common. In the hotel in which I stayed in Caracas, Venezuela, these great moths were a perfect pest. They were absolutely everywhere; the folds in the portières especially were full of them. Great numbers of dead ones were swept up from the rooms and corridors each morning.

The other casual visitor from the tropics is *Thysania zenobia,* much like the preceding but light gray with brown markings on the upper side and yellow and black beneath. Normally it just reaches southern Florida and southern Texas, but I once took one in Washington a few days after a hurricane had swept across the Florida peninsula.

Very much like this is the largest of all American moths, the great owl-moth of tropical South America (*Thysania agrippina*) which measures almost a foot across its wings.

This completes our list of giant moths, except for a few which are of more restricted distribution. The two last are only of casual occurrence. Most of the rest are common, and some are very common. You do not often see them, as they mostly stay high up in the trees and only fly by night. But if you know how to go about it you can get them easily.

What is the significance to us of these giant moths? In the first place none of them are sufficiently abundant to cause us serious trouble. The caterpillars of the polyphemus alone have sometimes proven destructive in limited areas; but they are large and easily controlled. The numbers of this moth are usually kept well within bounds by parasites and birds which kill the caterpillars, as well as by rats, squirrels and moles which tear open the cocoons and eat the chrysalids.

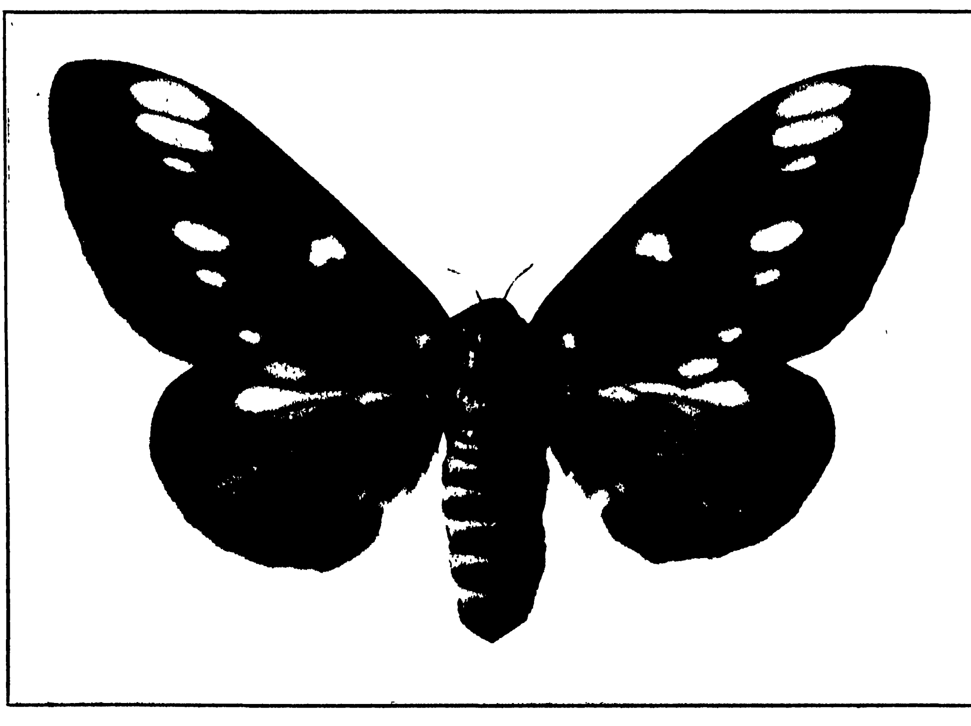

FIG. 18.—THE ROYAL WALNUT MOTH.

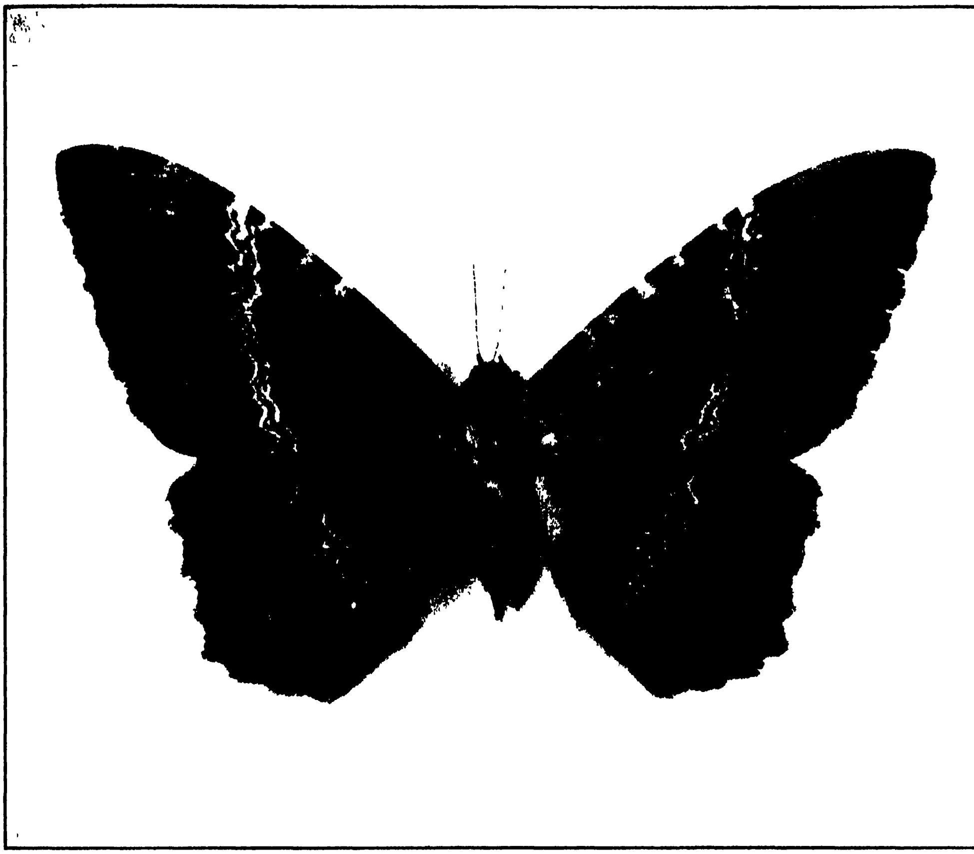

FIG. 19.—*EREBUS ODORA.*

Many efforts have in the past been made to utilize the silk in the cocoons. The cocoons of the promethea (Fig. 13) and the angulifera (Fig. 16) are so very dense and so very strongly gummed that the silk can not be reeled; but the cocoons of the cynthia, which are very much like these, are of a looser texture and are widely used for making silk in China.

The cecropia and its allies make a large cocoon (Figures 3–5) ; but in spinning it the caterpillar leaves one end open for the exit of the moth which prevents the reeling of a continuous thread, though it is possible to card the silk Although quite strong the silk has not much brilliancy, and the caterpillars are too delicate to be raised in numbers.

The cocoon of the luna (Fig. 10) is so thin and frail and the silk so weak that it is not possible to reel it.

The silk of the polyphemus has a very strong and glossy fiber and the cocoon is closed at either end (Fig. 9). Sixty years ago great hopes were entertained that this moth might become an important silk producer, like its relatives in eastern Asia. In 1865 on one estate alone not less than a million of these huge caterpillars could be seen feeding in the open air on scrub-oak bushes covered with nets, five acres of woodland were swarming with them.

But this thriving colony was wiped out by a disease brought to this country with the eggs of an allied moth imported through Paris from Japan.

ATOMS OF ENERGY[1]

By Dr. PAUL R. HEYL
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One of the earliest of the great scientific achievements of the nineteenth century was the establishment of the atomic theory of matter. The idea was not new. It had been suggested by the ancients; Newton and Boyle had used it as a working hypothesis; but the final establishment of the theory came only after the work of Dalton.

Prior to Dalton atomic ideas had been purely qualitative; he was the first to recognize the significant fact that whole numbers played an important part in chemical combinations. This fact, for which no explanation could be given on the hypothesis that matter had a continuous structure, was seen at once to be a simple and natural consequence of the theory that matter was composed of indivisible atoms which by their union with each other gave rise to the whole number ratios expressed by Dalton's laws of simple and of multiple proportions.

The fruitfulness of the atomic theory has been remarkable. The whole of modern chemistry is founded upon it; and while such physical phenomena as can be formulated by the principles of thermodynamics or of relativity may not, perhaps, require the atomic concept, in most physical theory it is supreme.

So long and so completely has the atomic theory dominated scientific thinking that many to-day may find it hard to realize that there could ever have been any other point of view, at least of late years; yet the theory that matter was continuous in structure had its adherents all through the nineteenth century, including men of the standing of T. Sterry Hunt, the geologist, who died in 1892. The last notable opponent of the atomic theory, Ernst Mach, of Vienna, died as recently as 1916.[2]

It is interesting to notice that this last adherent of a lost cause lived to see the atomic idea, after conquering the domain of matter, invade that of energy; for it was in 1900 that Planck[3] put forward the hypothesis that energy, which up to that time had been tacitly accepted as continuous in its nature, must be regarded as made up of indivisible atoms, or quanta. So fertile has this concept proved that it may be permissible to style Planck the Dalton of the twentieth century.

But just as the atomic concept was not entirely new to Dalton, so the idea that energy might be at least irregular in its structure had been suggested before Planck. J. J. Thomson, in his Princeton Lectures on the "Discharge of Energy through Gases" (1898, page 42), mentions with some wonder that by subjecting a gas to the action of X-rays the number of charged ions produced in the gas was very much smaller than might reasonably be expected. With hydrogen, for instance, less than a million millionth of the gas was ionized. Even with vapors of iodine and of mercury, much better conductors than hydrogen, the fraction of the gas ionized was still negligibly small. Thomson's explanation of this fact, later given, was that the wave front of the X-rays was not uniform, but rather of a beady or lumpy structure, the energy being concentrated in spots and spread out thin elsewhere.

[1] Published by permission of the Director of the National Bureau of Standards of the U. S. Department of Commerce.

[2] Brauner: *Nature*, June 28, 1924, page 927.

[3] Planck: *Verh. d. deutsch. phys. Gesellschaft*, 1900, page 237.

Only when one of these intense spots of energy happened to strike a gas molecule would an ion be formed, the thinner and weaker portions of the wave front being unable to produce this effect.

Carry this idea to its logical limit; concentrate all the energy in a number of spots of great intensity, with interspaces completely devoid of energy, and we have the modern conception of a light wave on the quantum theory. Such a wave front, if sufficiently magnified, would present not a uniform field of illumination, but a number of intensely bright spots rather sparsely scattered on a dark background.

Thomson's suggestion is interesting as a forerunner of later ideas, but like the atomic theory before Dalton it lacked the quantitative element. This was supplied by Planck; and as with the atomic theory, it was the quantitative touch which gave the new concept its fertility.

In putting forward the suggestion of the atomicity of energy Planck had not in mind the phenomenon described by Thomson, but was led to his hypothesis by a certain long-standing difficulty in the theory of radiation. Many attempts had been made to find a formula which should represent the distribution of energy in the spectrum of a glowing body, but without complete success. Agreement with experiment was in no case satisfactory in the region of the longer wave lengths, though fairly acceptable in all the rest of the spectrum. The accuracy of the experimental results did not escape suspicion; but careful and repeated work confirmed the discrepancy. Planck finally concluded that agreement would never be satisfactory on the basis of the existing ideas of the nature of energy. The new idea which he put forth is suggestive of Dalton in that he pointed out the importance of the part played by whole numbers.

According to classical ideas a vibrating molecule or atom might contain any amount of energy and lose it gradually by radiation, the retained energy diminishing in amount by imperceptible stages. Planck denied this, and asserted that the contained energy must always be a multiple of a certain fundamental unit called the quantum. This unit is so small (of the order of a million millionth of an erg) that it may be said that there is no perceptible difference between this and a continuous structure; yet the same might be said of atoms of matter. As a matter of fact, the sizes of both atoms and quanta are sufficient to make a noticeable difference.

According to the idea proposed by Planck, when a molecule gains or loses energy it must do so by sudden jumps, one or more quanta at a time, and not by a continuous change. The difference between this concept and the older idea may be illustrated by a box containing a number of equal marbles. If the contents of the box vary, it must be by jumps of one or more marbles; and the weight of the marbles in the box at any instant must always be a whole multiple of that of a single marble. But if the marbles be finely pulverized the whole numbers disappear, and continuous change is possible.

Revolutionary as was this concept it has abundantly justified itself and has doubtless come to stay. Applied to the previously unsatisfactory radiation formula it produced the change necessary to remove the discrepancy with experiment in the region of the long wave lengths without spoiling the agreement in the rest of the spectrum. This alone would have been a sufficient justification, but it was not all. Planck had builded better than he knew.

A similar discrepancy had long existed in the theory of atomic heats. Every student of chemistry learns Dulong and Petit's law, which states that the product of the specific heat of an element by its atomic weight is a constant quantity. Stated in this tradi-

tional form it is but a poorly obeyed law, for the "constant" turns out to have unexpected and unaccountable fluctuations, especially at low temperatures. Here we have again a law that fails at one end. It was but natural that the quantum concept, which succeeded so well in the similar case of the energy of the spectrum, should be called into play in this connection also.

The first to make this application was Einstein, whose contributions to the quantum theory have been so important that had he never written a word about relativity his reputation would still be second only to that of Planck. Einstein was followed by others (Nernst and Lindemann, Debye, Born and Karman) who added successive improvements to Einstein's formula until the erratic behavior of the atomic heat was satisfactorily expressed. Still again, in connection with the curious phenomenon known as the photo-electric effect, the new concept showed its power. Here the action of light upon certain metals causes them to emit electrons. Einstein applied the quantum concept, and succeeded in obtaining by its aid a satisfactory formulation of the phenomenon. But by far the most important and far reaching of all the applications of the quantum idea has been that by Bohr to the structure of the atom. This, however, is too long and perhaps too familiar a story to be told here.

In its successful application to these cases that we have mentioned the quantum concept finds its justification for existence; it works well where the classical theory breaks down.

It must not be inferred from this that the classical theory has suffered a complete rout, and that the quantum concept is an undisputed conqueror. Far from it. In certain matters, especially in the domain of interference, it is the classical theory that works well and the quantum concept that is helpless. The present situation as between the two theories is a deadlock. As Lodge says, the two concepts are like a shark and a tiger, each supreme in its own element, and helpless in that of the other. The solution of the difficulty lies undoubtedly in attaining some broader concept of which the two will be seen to be special cases.

As yet we have no satisfactory mental picture of a quantum. There is much to suggest the old idea of light corpuscles, but just as forcibly as a hundred years ago the phenomenon of interference puts an end to that. There must be something periodic in the structure of a quantum.

This conclusion is strengthened by the fact that different quanta have not all the same energy value. Their magnitude, measured in units of energy, varies with the source which gives rise to them. For example, the energy in a beam of red light appears to be made up of units each of the value of 3×10^{12} erg, while the units of violet light have double this amount of energy. The energy of a quantum is proportional to the frequency of the vibration of the source which emits it.

Attempts to visualize a quantum have not been lacking. One of the earliest suggestions was that it might be a train of waves of finite length, a "dart," as Silberstein called it. And since interference can be obtained with a difference of path of the interfering rays of fifty centimeters or more, it follows that a quantum would have to be that long; for interference can take place only between two trains of light that have started from the same source at the same time.

But Lorentz[4] called attention to the fact that a similar line of reasoning would indicate that a quantum must be several times as broad as it is long. In Michelson's work on star diameters interference was obtained from rays that were as much as six meters apart. The simile of the dart is, on such considera-

[4] Lorentz: *Nature*, April 26, 1924.

tions, replaced by that of a piece of corrugated iron roofing.

Moreover, a quantum of energy must be capable of entering the pupil of the eye, or of being absorbed by the much smaller electron, an operation suggesting the celebrated packing of the genie into a bottle.

It is evident from the contradictions arising from these different considerations that we are dealing with something much broader and more general than any of our present attempts to grasp it. In this respect we are like the three blind men of the Hindu story who went out to see the elephant. An obliging friend led them to the place where the elephant was, and said: "Now, there he is, just a few steps in front of you. Go and examine him." And they advanced slowly with outstretched hands.

The first man happened to touch the trunk of the elephant. He felt it up and down, and said: "How wonderful! An elephant is like a young tree with rough bark!" But the second, who felt the elephant's tail, said: "How can you say that! An elephant is much like a piece of rope!" And the third, who touched the side of the creature, said: "You are both wrong; an elephant is like a great, broad, flat wall!"

A notable attempt to form a mental picture of the quantum which shall be free from absurd contradictions has been recently made by J. J. Thomson.[5] He suggests that the quantum may be a ring or closed Faraday tube of force travelling through the ether unchanged in size or shape, surrounded by a system of Maxwellian waves, their wave length being equal to the circumference of the ring. This gives the quantum its periodic element, though Thomson does not regard these waves as instrumental in producing interference, nearly or quite all of the energy of the quantum being in the ring. The function of the waves is to guide the ring in its path as it travels.

Thomson considers the statistical average distribution of these quanta (which is all that the eye or photographic plate can detect) and comes to the conclusion that after passing a slit they will be spread out in such a fashion as to simulate the well-known appearance of interference bands.

The strength of this suggestion of Thomson's lies in its breadth and inclusive character. He recognizes that the undulatory and the quantum concepts both have a valid reason for existence, and attempts to combine them into a dual structure, one part of which is similar to that of the undulatory theory and the other to that required by the quantum concept. Both parts of the structure, ring and waves, have lines of electric force as a common foundation.

The effort spent in attempting to reach a satisfactory mental picture of the quantum is evidence of the recognition of the fact that the concept is here to stay, and that we must do our best at an understanding of it.

The inadequacy of the classical wave theory to account for such phenomena as have become familiar to us of late years is perhaps not widely appreciated. One of the best cases of this kind is found in the photo-electric effect. The argument is well summarized by Jeans in his "Report on the Quantum Theory."

There are certain metals such as sodium which emit electrons when light of a certain critical frequency or higher falls upon them. For sodium, this critical frequency is in the yellowish green of the spectrum, with a frequency of 5.15×10^{14} vibrations per second. Light of a frequency equal to or greater than this will cause an immediate emission of electrons, while light of any lower frequency, no matter how intense or long continued, will have no such effect.

[5] Thomson: "Fison Memorial Lecture," 1925. Cambridge University Press.

This immediate emission of electrons can be explained on the wave theory only by some sort of resonance or trigger effect. If there is in the sodium an electron vibrating with this critical frequency, and with such energy that it is just about ready to break loose, it might be that a very slight stimulus from the light wave would bring about the liberation of the electron. On this hypothesis we are to suppose that there are in the sodium electrons vibrating with all frequencies from the critical frequency upward, but none of lower frequencies. It appears impossible to reconcile such an idea with spectroscopic evidence. Every solid when heated to incandescence gives a continuous spectrum containing all frequencies, high and low; and even the more limited spectrum of gaseous sodium contains lines of lower frequency than the critical photo-electric value.

But without some such trigger effect the absorption of sufficient energy to liberate an electron would require more time than is actually the case. Campbell states this point excellently in his "Modern Electrical Theory" (1912):

> A photo-electric effect can certainly be observed when the energy falling per second on one square centimeter of the substance is much less than one erg, . . . and the energy of each electron liberated by it can certainly be greater than 10^{-12} erg. . . . On the ordinary theory of light an electron can not absorb more energy than falls upon the molecule in which it is contained; but the area covered by the cross section of a single molecule is certainly less than 10^{-15} square centimeter. It appears then that no electron could acquire the energy with which it actually emerges unless the light had acted for one thousand seconds, or about a quarter of an hour. . . . As a matter of fact, the effect appears to start simultaneously with the action of the light.

As a desperate attempt to retain the wave theory in such a case as this it has even been proposed to abandon or modify the doctrine of the conservation of energy. The difficulty is that there is not enough energy in the wave front at any point and at any time to do the required work, and yet the work somehow gets done. It has been suggested that when a continuous wave front strikes an electron the latter is stimulated so that in some way it actually creates in itself a quantum of energy, while to balance this there is an annihilation of energy over some other part of the wave front, not necessarily adjacent, and not necessarily happening at the same instant of time, so that statistically and on the large scale the balance is maintained. However, such experimental tests of this as are possible seem to negative the supposition.[6]

Recently what has been called the New Quantum Theory has been put forth by a group of physicists headed by Born, of Göttingen. We must not overunderstand the adjective "new" in this connection. The theory is simply a new system of mathematical formulation, and not a new mental picture. It has often been remarked that in their predilection for mental pictures and models the British physicists stand apart from their Continental brethren, who appear to be satisfied with a set of abstract mathematical formulas.

The student of the quantum theory as it stands to-day must not expect too much. The theory is but a lusty infant, though growing rapidly. Enough has perhaps been said to justify the statement that the quantum theory embodies the most important concept yet brought forth by the twentieth century. The theory of relativity, its only competitor, is already showing signs of reaching a barren stage, while the quantum concept, though some years the older, is still fertile and vigorous.

[6] C. D. Ellis: "The Light Quantum Theory," *Nature*, June 26, 1926.

PATHOLOGICAL PHYSIOLOGY

By Dr. STEPHEN D'IRSAY
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HUMAN physiology is a Janus-faced science. One of its faces is turned toward the wide sciences of biology: those making the *form* of living matter their study, as anatomy and its microscopic subdivision, histology and those investigating the function of organisms: comparative and general physiology. If we consider the enormous range of life, the varied forms which it assumes, passing in review at land and sea, in amoeba or mammal, the pure importance of human life, stripped of its associations, will dwindle. And still, emotional interest in the human body is such that human physiology outgrew all its due proportions and is now towering above the more general biological sciences. Here modern science goes arm in arm with Scripture and religion: all plants and animals of the world are made subservient to man's egocentric interest and even the "purest" scientist can not help but harken to the constantly recurring bearings of his particular science upon human physiology. Beyond biology, physiology leans back still farther upon the exact sciences: physics and chemistry and physical chemistry. And in the distance looms the quantitative thought, the mathematical thought. All physical science strives for a quantitative basis, all physical science is eager to create laws: It is ultimately *nomotopic.* And to reach this aim, two processes are necessary: (1) analysis, to simplify events and break them up into their components; (2) synthesis, upon the basis of broad induction which concludes in quantitative laws.

But physiology shows another face, too. It is turned toward the clinic, toward pathology. As Claude Bernard says: "La science ne consiste pas en des faits, mais dans les conséquences qu'on en tire." It is a general human tendency—supported by modern utilitarianism—to be pragmatic, and thus Bernard's consequences are apt to obtain a narrower meaning than intended by that great physiologist. The methods and results of physiology have been gradually translated into clinical terms and form the large foundations of modern internal medicine. All that is science in medicine is physiology because it is through her that the strict nomotopic demands of the exact sciences are felt and are complied with.

At one end of the scale, then, stands normal physiology. Its aim is the elucidation of the functions of the normal organism, both qualitatively and quantitatively. On the other end stands internal medicine, based and built, both on its diagnostic and therapeutic side, upon physiology—but evidently upon a changed and enlarged physiology. This physiology has for its aim the establishment of laws under which organs and organisms work *when diseased.* Of course, disease as a deviation from normalcy has often a scarcely discernible borderline. At one end the normal function may be retained, at the other, obliterated both in time and space. It is obvious, therefore, that normal physiology is at the bottom of explanation of all disease, but equally obvious that it is enlarged in scope. It has to consider deviations and their mechanism and in this widened scope fits in the new science of pathological physiology.

As to method, patho-physiology employs the method of the sister-science which is the experiment. On account of this method, patho-physiology quite often, particularly in Germany, sails under the name of experimental pathology. But experimental pathology may be primarily interested not so much in pathological changes of *function*, but in those of *form*, and then we have the experimental branch of morbid anatomy. There is such a thing as experimental morphology and we should isolate sciences regarding rather their scope than their method if that method is common to so many of them. I think that the influence of that famous statistician, Karl Pearson, is quite responsible for the persistence of methodological classification.

Let us consider the chief problems of this attractive science. In the field of the heart and circulation the ground is open in cardiodynamics. Normal physiology endeavors to establish the laws which govern the output of blood, the speed of the flow of blood through arteries and veins, and tries to set our whole knowledge of the circulation upon firm foundations of mathematical mechanics. This phase of physiology is becoming fast one of the most exact fields of physiology. The facts which it investigates are easily reducible to simple events, and methods of physics have been successfully applied. A step further is taken, when deviations from the normal function are produced. The methods producing these deviations are usually accessory to patho-physiology and might form part of another science in their scope. To illustrate: The valves of the heart very often show leakage, they do not regulate the movement of the blood from one chamber to another with accuracy but permit blood to regurgitate in the reverse direction. Such conditions can be experimentally produced by injuring the valves mechanically. Now, patho-physiology is concerned with the mechanism which results from such a leakage and it hopes that after the laws governing that mechanism are established, we will have a clear understanding of what goes on in the living human being under similar conditions. *How* the original anatomical lesion causing the leakage occurs is an entirely different question and would fall at present within the scope of experimental morphology whose aim it is to study the diseased *form*. I say *at present*, because all anatomical interest might be exhausted after a while and physiological problems—such as the behavior of diseased cells in the valves under the influence of infection, etc.—might come to the fore. Another great field for patho-physiology of the heart is the elucidation of various abnormalities within the heart-muscle itself—without reference to its dynamic aspect—the point of attack of the elegant method of electrocardiography. Or take the recent development in the study of the capillaries. Until recently the capillaries were neglected, neglected in spite of the fact that they form the bulk of cross-section of the total blood-containing equipment of the organism and that it is through them directly that the all-important exchange of oxygen occurs. Professor Krogh, of Copenhagen, pointed out the intricate mechanism and the widespread independence of these minute tubes and this important work opened up research into the changes of this mechanism in disease. Every phase of normal physiology has its immediate counterpart in patho-physiology, and not one but several counterparts, because there is but one normal condition, but the deviations from it are manyfold.

Very closely interwoven with the main function of the circulation, *i.e.*, the oxygenation of the tissues, are two other vital systems, that of respiration and the structure of the blood. The

study of respiration approximates the quantitative ideal of science: the intake and distribution of air (according to depth of inspiration) has been measured; similarly, the concentration of oxygen and carbon dioxide in the innermost recesses of the lungs. We know many details of the mechanism of the oxygenation of the blood, the limits of the saturation with oxygen, the factors influencing this saturation. Normal physiology teaches that the total quantity of hemoglobin (the oxygen-carrying pigment), the speed of the blood flow through the tissues, the (partial) oxygen pressure in the lungs are some of these factors. Each one of them may be expressed mathematically. Patho-physiology endeavors to alter these factors one by one and is at length able to find a mathematical formula for the pathologically insufficient saturation of blood with oxygen, a complicated condition, which the clinician expresses with the simple word "cyanosis."

The microscopic structure of the blood has been claimed as a separate field of medical science, so-called hematology. This field has been ploughed with great industry, particularly by Germans—so well adapted to painstaking detail work—but, from the point of view of *form* alone. A great field of pathological anatomy of the blood has been evolved with endless classification and nomenclature. The pathological physiology of the blood—which is a complex and important *organ* and not a mere passive "rolling stock"—is just beginning to rise. One of its interesting problems is the influence of the endocrine system upon the production of blood cells. It is very likely that organs like the suprarenal glands, the thyroid gland, etc., have a definite effect upon the creation of certain types of blood cells. A deviation in these relationships and there might develop the immensely complex group of "blood-diseases," diseases rather of the blood-forming apparatus (such as the marrow of the bones, lymph-glands, etc.).

The influence of these same glands upon our ability to resist infection is similarly a new channel. The suspicion is widespread among physiologists that most of the "anti-bodies," which are our main weapons against invading germs, are produced by the lining of the omnipresent capillaries. On the other hand, it is well known that these very capillaries can easily be influenced by hormones. Very promising combinations may thus be thought of which show that patho-physiology links together such widely divergent territories as endocrinology and hematology.

This brings us in contact with the study of infectious diseases. It is the province of pathological physiology to investigate the conditions—chemical and mechanical—under which a microorganism might attack the living tissue. It is further its province to investigate the migrations of these organisms and the production of poisons. Of course, much of this is open to anatomical methods, but there are many infectious diseases in which the localization and development of the specific poisoning can be determined solely by the experimental methods of physiology. Classical example in this respect is tetanus (lockjaw). The way the toxin of the tetanus-bacillus creeps up along the stem of nerves, the way it settles in certain portions of the spinal cord and the way the affected nerve cells change their reactions are all facts open to physiological experiment, but hidden to anatomic research. The complex phenomena of, *e.g.*, typhoid fever or the relatively simple ones of pneumonia—the latter deeply affecting certain chemical processes of the body—fall one by one under the domain of pathological physiology. The relationships between the "reaction" of the

body and the evolution of infections is another field inviting attention.

Metabolism is one of the most rewarding sections of pathological physiology. The discovery of insulin showing the intrinsic relationships of endocrine glands to metabolism brought this home to the public. But this discovery does not bring us nearer to the solution of the diabetes problem; science still fails to evaluate all the conditions governing the utilization of carbohydrates. Disentangling one fact from another in the erstwhile so chaotic chemical processes, pointing out the substances which are the turning point in the transition of one great group of food substances to another is the task undertaken by physiological chemistry, which in turn serves pathological chemistry. These are after all but branches of normal, respectively pathological physiology. The discovery of the "accessory" food substances was guided primarily by clinical considerations: by the recognition of "deficiency diseases." The physiology of an organism deprived of certain of its vitamins is pathological physiology, and this pathological physiology carries in and with it diagnosis and treatment of the resulting diseases. Pathological physiology is not only physiology. It *is* medicine.

Physiology has recently begun to utilize in an ever-growing degree the achievements of physical chemistry. This science covers the territory adjacent to both physics and chemistry. Many of its problems have been investigated in the human body and its very exact methods taken advantage of. Such problems are, taken at random: the permeability of the cells for various substances, the study of acidity and alkalinity of the organism and the intricate questions of colloid chemistry. All these problems have found their modifications in the light of pathology, and all the exact methods of physico-chemical physiology are now in the service of pathological physiology. This means that among many other things our understanding of one of the most vexed problems in medicine, that of Bright's disease, will be more complete. Anatomical research, which assumed the leadership in pathology for the past half century, although having admirable work to its credit, has to take the blame for the burdensome confusion now reigning in this particular field. Physico-chemical processes, however, are at the bottom of cell-life and so we really can not restrict the field of physico-chemical pathology to just one organ or one system. Its scope is immense and research just touched upon its possibilities. That research will slowly concentrate upon the functions of the diseased cells, giving a modern and exact rendering of Virchow's famous phrase, "Zellular-pathologie."

It would be easy to survey all organs and glance at the various workshops of pathological physiology; no organ is inaccessible any more, the operations of each one of them are being watched with keen interest both in health and in disease. This science offers the best opportunities for observation, the best methods of attack; and while it concentrates upon its chief aim, to wit, to establish *laws of disease* and put pathological happenings in the body upon a quantitative foundation, applying the experimental method, it also keeps its eyes open for data that nature offers in her ordinary pace. It would be an important and timely thing to round out and define the field of pathological physiology, fit her into a scheme of medical education, create a chair for her and start her on intensive and concentrated work. In one word, she deserves a place in the sun.

THE FILTERABLE VIRUSES AND THEIR NATURE

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IN the early days of modern bacteriology the discovery of a causative relationship between a number of bacteria and certain infectious diseases gave rise to the hope that ere long all infectious diseases of hitherto unknown origin would be linked up with organisms of this order. But notwithstanding most painstaking investigations in this direction, this hope was not fulfilled. This seemed rather remarkable. Smallpox, for example, was evidently not due to the activity of any one of the many bacteria which had from time to time been isolated from the pustules on the skin and the various internal organs. Such organisms were concomitant of the disease and responsible for some of its complications, but they could be ruled out as the causative agents of the malady proper. The fact, however, that association on the part of a single individual with a smallpox patient could give rise to a widespread epidemic of the disease was evidently an indication that the causative agent underwent rapid and extensive multiplication, and multiplication naturally suggested the activity of living matter. As bacteria were then viewed as the lowest forms of life, it seemed to follow that a bacterium must be the cause of such a disease as smallpox. Similar considerations seemed to apply to many other diseases affecting both man and animals, such as hydrophobia, infantile paralysis, mumps, trachoma, measles, the hoof and mouth disease of cattle, hog cholera and many more. As bacteria such as they were known until very recently could be seen with the microscope, but as no bacteria that had any causative connection with the corresponding maladies could be discovered in the affected organs, the question naturally arose whether low forms of *animal* life, visible only with the microscope, might be responsible. A number of infectious diseases, like malaria and amoebic dysentery, had as a matter of fact been traced to protozoa, as the lowest known forms of animal life are termed. There yet remained a large number of very evidently infectious diseases, however, in which neither by attempt at cultivation or by means of the microscope evidence of the presence of foreign living matter could be detected.

In view of this situation two possibilities suggested themselves as affording an explanation of the origin of such diseases. On the one hand, it was conceivable that living organisms might exist which were too small to be seen with even the very excellent instruments which were available at the end of the last century. On the other hand, there arose the question whether mere infectivity on the part of a disease necessarily implied the activity of an animate agent.

The idea that ultramicroscopic organisms might exist was suggested already by Pasteur, when he failed to find bacteria in the brain and spinal cord of animals which had succumbed to hydrophobia, while the inoculation of minute quantities of such material into other animals produced the malady in question. Subsequently the belief in the existence of apparently invisible organisms and their causative relation to infectious diseases of unknown origin gained many

adherents, but it was not until 1892 that a disease-producing agent of this order was actually discovered. In that year a Russian scientist, Iwanowski, demonstrated that an infectious disease affecting tobacco could be transmitted to healthy plants by inoculation of small quantities not only of the freshly expressed juice obtained from sick plants, but even after filtration through stone filters of great density. In 1896 Iwanowski's observations were confirmed by the Dutch scientist, Beijerinck, and at the same time greatly amplified. Inasmuch as the infective principle of the disease was capable not only of passing through dense porcelain filters with which Beijerinck worked, but permeated thick layers of a dense agar jelly, this investigator drew the inference that the agent in question could not be an organized body. As the inoculation of the minutest trace of the infective material into healthy plants produced the disease, and as this could be transmitted, moreover, through long series of plants with the resulting infection of the entire body of the plants, he concluded that the mysterious agent in question must be endowed with life, notwithstanding the supposed absence of a corpuscular form. He accordingly developed the concept of a contagium vivum fluidum, *i.e.*, of a non-organized but animate disease-producing body. This concept, it must be mentioned at once, could not be upheld, for it was shown subsequently that the permeation of the infective principle was after all the permeation not of a substance in solution, but of a corpuscular body of such minute size that its constituent particles were capable of entering even such minute pores as exist in agar jelly.

In the same year in which Beijerinck published his findings, and apparently in ignorance of the latter's work, Löffler and Frosch made the announcement that the dreaded hoof-and-mouth disease of cattle was found by them to be due to an apparently invisible agent which was capable of passing the pores of the finest stone filters and of infecting in mere traces. Notwithstanding their inability to demonstrate anything visible either directly or in attempted cultures of the filtrate, they concluded that the principle in question must be animate.

The reason for this, as in Beijerinck's work, was the observation that by starting with a minute quantity of the infective material they could serially infect an unlimited number of animals, and that healthy animals, when placed in the same stable with such that had been inoculated with filtrates, nevertheless contracted the disease. In other words there was abundant evidence to show that the infective agent underwent reproduction and that the possibility of serial transmission was not due to progressive dilution.

Löffler and Frosch were fully aware of the significance of their discovery and expressed the view that subsequent research would probably establish that yet other infectious diseases of heretofore unknown origin were caused by ultramicroscopic organisms.

The search for microorganisms of this type was then begun by many investigators and is going on even more actively at the present day. As a consequence a long list of infectious diseases affecting man and many animals, as well as plants, is now known to be caused by filterable viruses, as these agents are collectively called. The term "virus," of course, has reference to the infectious, pestilential nature of the maladies caused by these organisms, and the attribute "filterable" to their extremely minute size, in virtue of which they can pass filters which, generally speaking, hold back all other types of living matter, *i.e.*, bacteria and protozoa. Of the diseases in question which affect man may be mentioned hydrophobia, smallpox, infantile paralysis, measles, mumps and trachoma, which is responsible for

so much misery the world over. Even the innocent fever blisters, of the actual significance of which in relation to those diseases which they accompany, nothing is as yet known, common warts and certain febrile diseases, such as dengue, so-called pappataci fever and possibly chickenpox and the type of sleeping sickness which has appeared of recent years in the wake of influenza epidemics belong to this order. Some investigators, on the basis of an increasing number of successful inoculation experiments in animals with tumor material which had been passed through stone filters, further incline to the view that malignant growths affecting the human being even may be due to agents of this type.

Among the diseases which affect animals an equally large number have been traced to the activity of filterable viruses, many of which are of great economic importance, such as hog cholera, cattle plague (Rinderpest), chicken plague, poultry pox, several infectious maladies affecting sheep and goats, certain diseases of horses, possibly also the distemper of dogs and many more, in addition to the hoof-and-mouth disease in which Löffler and Frosch made their basic discovery. Even among the lower animals filterable viruses play an important rôle. In the case of the silkworm a certain infection of this order leads to disastrous consequences and may cause great economic losses. A closely related virus attacks gipsy moth caterpillars and causes a fatal disease among these, but unfortunately from the standpoint of the agriculturalist it seems to be difficult to bring about sufficiently extensive epidemics of this malady to serve as a serious check to the activities and extension of these insects.

As has been mentioned at the outset the existence of filterable viruses was first discovered in connection with a disease affecting tobacco. This is known to plant pathologists as mosaic disease. While it does not lead to the destruction of the plant it renders the leaves unsuitable for wrapping purposes and detracts from its proper aroma. Similar diseases have been found to affect a large variety of plants, in some of which the activity of a filterable virus has already been definitely established, while in others this is as yet only suspected. When affecting such plants as corn, sugar cane and wheat the malady produces great losses, owing to the effect which the viruses in question have on the growth and development of the plants.

A few years ago certain observations were made which suggest that even the lowest class of plants, *viz.*, the bacteria, may become attacked and succumb to the action of a filterable agent—the so-called bacteriophage—and that this process can be induced serially as in the case of the virus diseases to which animals are subject. Much of this work was initiated and developed by d'Herelle, and an impetus was thus given to investigations which have opened up new fields for study, the importance of which can even now hardly be estimated.

In the earlier days of the study of the filterable viruses the mere fact of their ability to pass stone filters, whose pore size was such as to hold back all the then known bacteria, was regarded as a sufficiently characteristic criterion to serve as a dividing line between the visible and the supposedly invisible animate world. Later researches, however, have demonstrated that bacteria exist, which either owing to their form and power of locomotion, even ordinarily, *i.e.*, at any stage of their lives, are able to pass filter pores which hold back other bacteria, or which at a certain stage of their development assume such a minute size as to enable them to do this. Such filter passing organisms, however, can not be viewed as filterable viruses proper, for all of them can be cultivated on artificial media where they form colonies which can for the most part be seen with the naked eye

and without difficulty with even the lowest powers of the microscope. The filterable viruses proper, on the other hand, can hardly be said to be cultivable on artificial media, and where some semblance of their at most temporary persistence under such conditions has been noted colony formation has never been observed. In the very few instances where actual unlimited propagation has been achieved outside of the body, this has been brought about by the use of artificially grown tissues of the host animal which the viruses in question are normally capable of parasitizing. The filterable viruses, as a matter of fact, appear to be highly specialized parasites which are incapable of existing outside of the animal or vegetable body, and in many instances apparently even outside of certain tissues or even of certain cells.

In some diseases it is possible to make out the presence in the affected cells of enormous numbers of tiniest granules, so tiny in fact that an ordinary bacterium in comparison appears like a perfect giant, and some investigators incline to the belief that these granules represent the corresponding virus particles themselves. In other diseases, however, it is not possible to discern anything showing any form, even with the highest powers of the microscope. Nevertheless, even in these it is possible to demonstrate that the infective principle is corpuscular in character, *i.e.*, that it is not a substance present in solution, but a particle held in suspension, for on filtering material of this order through so-called ultra filters of progressively diminishing pore size, one ultimately reaches a point where the virus is held back, as is evidenced by the absence of infectivity of the filtrate. As it is possible to determine the pore size even of such dense filters as these, it is also possible to determine the size of the infective virus particle. Studies in this direction have led to the discovery that some of the filterable viruses, such as that causing the mosaic disease of tobacco and the virus of chicken plague, must have a diameter of only thirty millimicra, one millimicron representing the millionth part of a millimeter, and one millimeter being equivalent to 0.03937 of an inch.

The discovery that some of the filterable viruses are of such a minute size has naturally raised the question whether they can possibly be animate. If we look upon their evident multiplication in the infected host as evidence of reproduction *ex eo ipso*, *i.e.*, as resulting from the successive division of the virus particles, then we must also assume the existence in such particles of a process of nutrition, both of a constructive and a destructive type, and such an occurrence, so far as our present knowledge goes, would doubtless imply the existence of life. But inasmuch as the diameter of the infective particle is such that the corresponding cubic contents would hardly admit of the presence of even such a comparatively simple nutritional and reproductive mechanism as the smallest of the common bacteria possess, we must assume such viruses to be much more simply organized, and this in turn raises the question whether we would have the right to regard such organisms as bacteria in the ordinary sense of the word, and, if not, what are they.

Hitherto we have been in the habit of looking upon bacteria, such as we can see through the microscope, as the lowest forms of living matter, but in view of the fact that infinitely smaller organisms are now known to exist, the question arises whether it is rational to assume that in the evolution of living matter from non-living matter the chasm between the two was crossed at one leap, or whether it does not seem more likely that it was gradually filled in and crossed by degrees. In other words, the question is whether between the most lowly organized bacteria and the type of non-living matter from which living matter was derived, there may not have

developed a world of living organisms as extensive and as varied perhaps as the world of living matter that we see before us to-day, either with the naked eye or aided with the microscope, but a world of life of whose existence until recently very few had ever dreamed. While the writer is willing to admit that future research may show that some of the organisms which are now classified among the filterable viruses may prove to be bacteria or protozoa in the present concept of these terms, having perhaps been modified in their behavior in consequence of their exclusively parasitic existence through the eons, he is inclined to look upon these smallest forms, which may properly be termed ultraviruses, as representing living matter of such intermediate type, the existence of which we have postulated on theoretical grounds.

As we have reason to believe that the number of species of bacteria which are pathogenic for higher forms of life only represent a small fraction of the entire bacterial world, it would seem logical to assume that in a world of still more primitive living matter, also, only a certain number would be endowed with disease-producing properties in reference to higher forms of life, and those which were capable of attacking man and the domesticated animals, more particularly, would naturally be the ones which in the course of time would first attract the attention of investigators and thus lead to their discovery. To demonstrate the presence of these disease-producing forms in a given instance, and in particular their animate nature, is often a very difficult matter, but to penetrate the realm of the corresponding non-pathogenic, *i.e.*, non-disease producing forms is from the nature of conditions infinitely more so. Only a very occasional investigator has, as a matter of fact, attempted to enter this domain, but has encountered portals which ordinary keys evidently are incapable to unlock. It does not follow, however, that with more suitable methods an entry may not be effected. Whether or not d'Herelle actually had a glimpse into this world when he found that ultrafiltrates from a certain sulphur spring brought about the reduction of mineral sulphates under laboratory conditions remains to be seen. The field is so vast and the workers along these special lines are as yet so few that much time will probably have to elapse before our knowledge will be materially increased.

At the present time it would seem indicated to concentrate our efforts on the study of the filterable viruses proper, *i.e.*, on that group of protobes, as all these forms of ultra primitive life might collectively be termed, the existence of which is recognizable by the diseases to which they give rise.

It has been pointed out above that the animate nature of this group would appear to be indicated by the power of its members to produce disease in series, as this would suggest their reproduction *ex eo ipso*. But the question has been raised of late whether the mere possibility of serial transmission of a disease constitutes actual proof that the causative agent must be living. In this connection certain observations of Baur are of special interest. This investigator found that a disease affecting certain plants, which is known to plant pathologists as infectious chlorosis, can be serially transmitted, but not by the injection of the juice of diseased leaves. But, if a diseased twig is grafted on a susceptible plant and the graft has once "taken," the malady appears in all leaves which are at the time in process of formation or which are subsequently to be formed by the host plant. Any one of the resultant twigs, when placed in suitable soil, will develop into a similarly diseased plant. It is thus clear that the disease-producing principle is being reproduced, but inasmuch as it

does not appear in the juice of the diseased leaf in an infective state, it would seem that it must cause the outbreak of the malady in hitherto healthy parts of the plant in an indirect manner, and certain investigators have accordingly assumed that it can not be animate. Whether this conclusion is warrantable on the basis of the observed facts may perhaps be questioned, but, if the active principle were assumed to be animate, we would be confronted with a manifestation of life which could certainly not be reduced to living matter of any type with which we are acquainted. The recognition of the possibility, however, that a serially transmissible disease need not necessarily be due to an animate agent, has raised the question whether some of the filterable viruses may not be inanimate, and if so, of what nature the principles in question may be. This question has arisen more especially in connection with those viruses which are capable of passing some of the denser ultrafilters, such as the virus of chicken plague and the bacteriophage. In connection with the latter the strife betwixt the supporters of its animate nature and those who regard it as inanimate, has indeed been a very strenuous one, and it would seem that in spite of the enormous amount of work that has already been done, the question was as yet far from being settled. d'Herelle, the discoverer of the bacteriophage, has advanced many weighty arguments in favor of his contention that it is a living organism, and arguments, moreover, which his opponents have often overlooked or at any rate failed to meet. Some of his opponents' claims regarding the nature of the bacteriophage certainly appear just as fanciful, to say the least, as his own.

In connection with the study of certain infectious tumors of fowls which appear to be closely related to, if not identical with certain cancerous growths affecting the higher animals, including man, the same question has been raised. Here also the active agent is a filterable virus which is capable of producing these tumors in series and shows a number of characteristics which we have been in the habit of connecting with living matter. But, as it has been possible to produce these tumors artificially by injecting fowls with minute traces of chemical substances of known composition, together with normal embryonic tissue, with the resultant appearance of a filterable agent which is capable of producing the same type of growth in series, it would seem, on first consideration, that this agent could not be animate. If, however, we were to assume that we have present, widely distributed in nature, a living virus or viruses which, while usually innocuous, could be rendered disease-producing (in this instance tumor-producing), under such conditions or similar ones to those which we have just set forth, we could understand how an animate filterable, tumor-producing agent might appear in the resultant growth, with which the same types of growth could then be reproduced in series. The sequence then would be the development of more or less specifically diseased cells in the host, the invasion of these by an ordinarily innocuous, more or less omnipresent animate virus, and the consequent transformation of such diseased cells into cancer cells. Whether or not this is the process or one of the processes by which cancers actually originate is now under consideration. Many facts could be adduced in support of such a hypothesis.

The question, of course, arises whether we have any evidence that viruses actually exist which may be present in the body without causing disease at one time, while at other times they produce harmful effects. Our knowledge along these lines, it must be admitted, is as yet very meager, but we do know at least of one virus which manifests such a behavior. The virus in question is one which is responsible for the formation of the com-

mon fever blisters and those forms which in the layman's mind are referable to some disorder of digestion. Medically this condition is spoken of as herpes simplex. In certain febrile diseases, such as pneumonia, it is especially common, so common indeed that we could predict its appearance with a fair degree of accuracy in a given case. As its appearance follows the outbreak of the pneumonic process the question arises, where was the virus before? Three possibilities suggest themselves, *viz.*, (1) that the virus entered the body with the pneumococcus (the pneumonia-producing organism), (2) that it entered following the latter's invasion, or (3) that it was previously present in the individual's body in an innocuous form. If the second possibility represents the actual situation we would be forced to assume a nearly ubiquitous occurrence of the virus of herpes and its activation by the pneumonic process. This would virtually amount to the same as the third possibility, as in the absence of the pneumonic process invasion, even if it did occur, would not be followed by an attack of blisters. In connection with the first possibility we should be forced to assume a coexistence of the virus with the pneumococcus, but of this we have as yet no experimental evidence. The fact, however, that herpes develops in so many people in the absence of an infection and frequently periodically, would suggest that the third possibility, suggested in connection with pneumonia, is probably the more likely one.

It would thus appear that the possibility of producing tumors—in the fowl at any rate—by the injection of chemicals and embryonic tissue, does not exclude the cooperation of a virus, and no sound argument has as yet been raised to warrant the assumption that the filterable tumor-producing principle which appears in the resultant growth is not animate. If, as Carrel claims, these chemically produced tumors are identical in nature with the spontaneous tumors which occasionally occur in chickens, and of which the so-called Rous tumor is a typical example, additional evidence of the animate nature of the corresponding virus or viruses would be available, for Rous has shown that the virus discovered by himself is capable of adaptation. When he first encountered a malignant tumor in a chicken, of which a filterable agent was the cause, he found that this particular growth, be it by grafting or the inoculation of filtrates, could only be transmitted to other chickens if these were of the same variety, and at first indeed members of the same family. In the course of time, however, he succeeded in transmitting it to other varieties as well, and at the present time the same strain of virus seems to have lost all the host specificity which it originally possessed; it has gradually adapted itself to chickens in general. The power of adaptation after all implies the ability to exist in an unaccustomed milieu, and when coupled with evidence of reproduction under such conditions implies the existence of life, and considered from this point of view all the filterable viruses, so-called, with which we are at present acquainted, may more appropriately be regarded as animate than as inanimate.

THE ODYSSEY OF SCIENCE

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In making a modest study of the text of Herodotus, so far as was possible for one who knew little Greek, I attempted two or three years ago to cull from it something for the readers of this journal which might arrest the attention of scientific men.[1] In the course of the work I was led to the desire to attempt to supplement it by reading the Odyssey for the same purpose, but other interests intervened. In selecting from my notes[2] now I find it best to pick up the thread of interest in the Odyssey in the article on the Science of Herodotus.

It is not a matter that warrants farther extension here, but I was somewhat surprised to find the latter had evidently borrowed his information in regard to Libyan lambs being born with horns[3] directly from Homer.[4] We get at once the revelation which is easily to be found in Greek literature that Homer was, after five hundred years, the source of science, religion and history from which men largely drew their inspiration in the zenith of the glory of Greece. Herodotus has dated Homer for us four hundred years before he himself was born, and we see him dipping here into his lines for one of his diversions from the paths of history, which is the way he says he likes to write it. It is a pity more of science and more of history can not be written in the same way. This may have been one of the crumbs Aeschylus says were being constantly picked up from Homer's table, but as there are in Herodotus extended remarks of biological interest on the subject, it may still in his day have been an interesting piece of knowledge to be picked up among the Egyptian savants where Homer himself may have found it.

This, however, was observed afterwards and was not what especially struck the spark that blazed into my desire to read the Odyssey in Greek. In the article in this journal referred to above I displayed some interest in the growing literature of the lost Atlantis. It is very astonishing to note the volume to which in various forms this has grown. Despite the very decided way in which geological science has negatived the assertion of the plausibility there is in Plato's tale—all science in fact has contributed its disapproval of any time spent in the discussion of such a notion —that not long before historic times, geologically speaking, a continent sank below the waters of the Atlantic beyond the Pillars of Hercules and perhaps carried down a civilization with it, still the discussion goes on. Even since the recent date of the note of interest I let drop in the matter, two or three years ago, a great deal of more pretentious and of course more important publication in regard to the old old tale has

[1] Scientific Monthly, June, 1923.

[2] Besides the Oxford text by Monro and Allen, I have had advantage of the four volumes thus far published of Bérard's work, the text and introduction with its voluminous comments and critical remarks, also of Allen's Homer, Origins and Transmissions. These, published in 1924, are the latest additions to interminable lists of similar works on the Iliad and Odyssey to be had for the asking in the larger libraries, stretching back to Pisistratus, 2,500 years ago. The Unity of Homer, by Professor Scott, 1921, has also been in my hands.

[3] "Herodoti historiarum," libri IX, ed. H. R. Deutsch (Teubner), IV. 29.

[4] "Homeri opera," Monro and Allen, Oxford, Od. IV. 85.

seen the light. Not to more than mention such excellent books as Spence's[5] and Dévigne's,[6] whose authors make no attempt at original scientific analysis, there has on the contrary been published some work very worthy indeed of serious scientific examination. How much weight the argument of Brousseau[7] in a critique of the Wegener-Joly hypothesis of cosmogony has with geologists I do not know, but Schmidt in tracing the birthplace of eels, from two continents at least, to the supposed site of the Atlantis can not fail to arouse the interest of biologists in the theory of an inherited instinct in eels' plasm to seek for their birthplace a situation where perhaps ten or twenty thousand years ago they had riparian rights. Something analogous has been worked out for salmon. The article of Louis Germain,[8] assistant at the National History Museum at Paris, is still more suggestive from a biological standpoint. His citation of the land and marine life of the eastern brink of the Atlantic and its homologies with that elsewhere and with the paleontological evidence may be refuted, perhaps, but it can not be ignored. These authors conclude that the only rational hypothesis which can explain the facts they and others adduce is to assume the existence once of an ancient continent which extended over the rather vaguely placed area of the Sea of Saragossa which the *Arcturus* has been unable to find and as far eastward as the Atlantic islands which lie off the coast of northern Africa.

Far be it from me to presume to enter into any review of the highly technical biological and geological and archeological and ethnical and historical—for the evidence permeates all these domains which enters the endless arguments on the subject. I only take this opportunity of referring to the recrudescence of the discussion. In going over some of it in a desultory way I noted a reference to a passage in the Odyssey which supported the author's rather visionary speculations on the subject, but he did not give chapter or verse and I myself forget the book or article and its author's name whence I got the hint. I set out to find anything in the Odyssey to warrant it in various translations, but missed it. Annoyed, like the Chinaman who burned down his house to roast the pig, I turned and read the whole text through and it has carried me far into a land of delight, while the original trifling excitation to enter it almost passed from view, so I do not know whether this was what the author busy with the question of the Atlantis meant or not. When Nestor in sandy Pylos is in talk with Telemachus in search of news of his father he advises him to seek out Menelaus, who on his way home from Troy, lately returned, had come from a strange country—from the land of men whence none would hope in his heart to return when once the storms have driven the wanderer into so wide a sea. Thence even an eagle or a vulture could not make its way in the space of a year, so great a sea it is and so wide. That is somewhat the way Butcher and Lang translate it, I found after I had lingered long enough over it in the text for me to think what some one had said about the Atlantis. There were one or two expeditions, much more complicated than the one fitted out by the son of Odysseus to hunt his father, which were, as I read, being equipped to try to drag up some scrap of loose ware from that sunken continent whence it took the birds so long to come in view of old Nestor at sandy Pylos, out past the Pillars or Pyloi of Hercules towards Sandy Hook. The present is linked up

[5] "The Problem of the Atlantis," by Lewis Spence, London, 1924.

[6] "L'Atlantide," by Roger Dévigne, Paris, 1924.

[7] *Revue Scientifique*, 1924, Nos. 15 and 16.

[8] *Revue Scientifique*, 1924, No. 15 and 16.

with the past by a thousand subtle ties and perhaps the old hero had dimly in his mind the story that was old long before Plato wrote or Homer sang.

Jowett thinks very likely Plato invented the story himself to begin with. He was quite capable of it, he thinks. Homer, no doubt, invented a lot of things about Troy and we moderns for centuries believed he invented Troy, but it has not proved so. Nestor he may have invented, but it is likely there were mariners' tales of very many things, of very many lands, and some of those tales we can be sure were lies and that distant shore whence the sea eagles came, if strong enough of wing, recedes for us into impenetrable mist. Still—

Some of those mariners with lies to catch the land-lubbers they traded with were Phoenicians who heired the naval power of Crete when it fell and Knossus was sacked. It may have been the Cretans who brought the news of the sinking of the Atlantis; indeed, the sea power of Crete has been advanced in the argument as to how the tradition arose, but such blatter is such stuff as dreams are made of. Who knows, however? The sea power of Crete may once have been a great factor in the life of the Mediterranean civilization and when the empire fell it was a cataclysm indeed that was heard all around the little world of the Middle Sea. That might have been the mighty power that sank into oblivion. That very likely was news, some suppose, the Phoenician merchant pirates told in the old sea ports and thus the story became a continent which sank beneath the waves. That is the only news, so far as we know, the Phoenicians could have been old enough to carry. It may have indeed been a very garbled story in the mouth of one so wise, but so old as Nestor. As the Odyssey flows along we never think it is not Nestor speaking, but Homer, so realistic and impersonal is he. Homer too doubtless gathered his inspiration not alone from the breath of the sea and the surge of its waves, but from the mariners who sailed it and dropped into every port to liquor up.

While ethnologists, turned historians, as so many scientists tend to become nowadays, may be interested in the ethnic origin of the Phoenicians and may be compelled to turn over the pages of history to get some insight into that mystery, the interest of all scientists is attracted by the advent in history of the invention of letters or rather their evolution to portable and cursive script. There is another matter, parallel in a way, in the history of the knowledge of iron which recedes also into obscurity. The practical use of both bids fair now to be dated more or less definitely and with both we find the activities of the Phoenicians intimately connected, evidently not as inventors or discoverers of either but as carriers of both. The fateful letter Bellerophon bore to Iobates was something graved in a folded tablet.[9] We know that the author of this line in the Iliad was familiar with the art of writing letters in very portable form and that marks, not by any means the first recorded instance possibly, but it marks an event pregnant with interest for the historian of the evolution of civilization. It has lain before the eyes of men for 2,500 years unrecognized before modern archeology was born. It may be said this is history only by inference, but it acquired significance when fifty years ago we had to accept Troy as a fact and its situation in sight of the rushing tide of the Dardanelles, where there must often have been a portage across land for commerce, has rendered a Trojan war, or many of them, almost a certainty without any other argument than the geographical one. It has needed the acquiescence, however, of

[9] Iliad, VI. 169.

Sir Arthur Evans[10] for us to accept the identification of Atreus, the father of Agamemnon, by Dr. Emil Forrer among the findings at Boghaz-Keu, dating him at 1240–1210 B. C.

Although by this time we have hardly needed the reference in the Hittite records to a real Atreus to convince us of a real Troy Miss McCurdy[11] has added to our satisfaction in slowly realizing that Homer has historical value by noting that the breastplate of Agamemnon[12] came to him from a Cyprus vassal of the Atreus named in the Boghaz-Keu records. It has however further interest for us here than the demonstration of the purely politico-historical value of Homer to find Miss McCurdy thinks of steel used in the armor. The shield was made of twelve strips of gold, twenty of tin and ten of some blue metal which may have been steel, but the fact that the Homeric Greeks knew how to harden iron into the cutting edge of steel is plainly set forth in the Odyssey,[13] for there the blacksmith gets the full virtue of the iron in the axe by plunging it hot from the fire into cold water. The process was evidently a familiar one, for the description forms an illustration to enlighten his hearers as to something else. He would never have used one unfamiliar to them in this connection. A much later date has been ascribed to the revelation of the magnetic attraction of a Magnesian stone, at least to the western world. The knowledge of the properties of meteoric iron in all probability goes far back in the history of primitive man. He added doubtless this magnetic function of it to its falling from the sky as a reason for worshipping it. In the Odyssey it is associated, as a metal hard to extract from the ore, with other metals, bronze and gold,[14] and elsewhere it is said "it draws men to it."[15] One can hardly doubt this is one of Homer's quiet jokes, recognizing it as in the class of the precious metals, but alluding to the magnetic power frequently found in sidereal iron. I can see no reason why Sir Richard Glazebrook[16] should conjecture its magnetism was not known to the western world until 600 B. C., two or three hundred years after Homer seems to allude here to it as "drawing men." Such species of humor is very characteristic of Homer, in the Odyssey at least, a play on words being often apparent even to the tyro reading Greek.

Getting back to the Phoenicians, however, as ocean carriers, we can realize the weight and bulk of such heavy merchandise would preclude the metal being familiar to Mediterranean men in the light vessels of the epoch, until its chief usefulness as steel set the pirate traders of Tyre and Sidon carrying this munition of war and instrument of the arts everywhere, and it seems very likely from the Homeric poems, coinciding with much other evidence, this expansion of its use began somewhat near the time of the Trojan war and was well developed when Homer wrote. Homer apparently knew of steel, but he knew too it was not much in use for weapons at the time the war raged around Troy. His hearers could no more be told Achilles used a steel-tipped spear than readers in 1926 could be told machine guns were used at Bunker Hill. The Phoenicians carried iron in Homer's day, because people everywhere were learning to put an edge on it. They had carried their account books, too. The supercargo with his scroll, checking off the articles as they were carried ashore, must have been an impressive spectacle to the untutored Pelasgian or the quick-

[10] *Journal of Archeology*, July–December, 1924.

[11] *Ibid.*

[12] Iliad, II. 19.

[13] IX, 392.

[14] XXI, 10.

[15] XVI, 294.

[16] SCIENTIFIC MONTHLY, March, 1925.

witted and unlettered Dorian, but recently come over the mountain passes from the north. The Phoenicians, however, stand out in the Homeric poems in a rather evil light. Homer, following the bad example of the Christians, later gives them a bad name, maligning them doubtless as underhandedly as those now taught to speak no evil of any man. The Phoenicians were Semites, perhaps Jews, and knew as well then as now how to beat the Greek at a battle of the wits, and the Greek poet in his heart cursed them. To us they are significant as merchants who spread the arts of civilization from the Orient bordering on the Middle Sea to the Occident even beyond the Pillars of Hercules, as far as the shores of Britain and no doubt beyond. It is not at all impossible they may have injected that faint reflection of Babylon claimed for the saga of the Nordic tribes around the North Sea. That the Phoenicians were Semites or of allied blood seems a rooted belief in archeologists. In the Odyssey the swineherd[17] tells a bad tale of his own undoing and it brands them as pirates and manstealers, but bold and unrivalled mariners. We get more than one reference to this sort of thing and we infer that the practice was not confined to the Phoenicians, for one of the haughty wooers exclaims,[18] angered at the words of the friends of the disguised Odysseus: "Come, let us throw these strangers into a many thwarted ship and send them away to Sicily where they will bring a good price." Mariners have always been a hard set and harshly treated ashore, liable to kidnap and liable to be kidnapped even in times not so very far back, but through them in Homer's time, when there was no flag for commerce to follow, civilization followed in the wake of pirates.

The Cretan and Phoenician merchant made piracy a part of his trade no doubt. Minos in his time is said to have checked the former, but it bloomed again in the time of Homer when the Phoenicians had succeeded the Cretans on the sea, or that seems likely as we interpret the Homeric poems in the light of modern archeology. The corsairs of England of the same ilk, though not of the same blood, so also those of the Barbary coasts for hundreds of years, were such merchants of the sea. All did it who followed the sea. Plato insists[19] not only has the sea brackish, bitter water, but it begets in the souls of men uncertain and unfaithful ways. "Naval powers, which owe their safety to ships, do not honor that sort of warlike excellence which is most deserving of honor." I suppose Plato had Homer's Phoenicians in his mind when he wrote thus, but that there were others, that a piratical turn of mind was characteristic of all seafaring men he knew is also evident from his generalization. Crime followed in their wake. Swift-going rum boats and swift-moving motors present now the same results from the same fundamental cause —superior speed and skill. They have always had a sort of credit with loose-minded people because of it, and Homer makes no attempt to hide the Phaeakians were pirates and yet had for sovereigns the most generous of kings and the most virtuous and the wisest of his women. Fine shades of distinction did not exist then and are still difficult to draw between big business and piracy. The greatest benefactors of the human race seem in the days of Homer to have been pirates. This is a queer world. Everything passes and everything remains the same.[20] In Hades meeting Agamemnon Odysseus asks him naïvely if he had been killed on his way home, burning cities, raiding cattle and raping women.[21]

In reading of the rich gifts with which Alkinous, the King of the Phaeakians,

17 XV, 415.
18 XX, 382.
19 Laws IV, 705, 706.
20 VI, 270, *seq.*
21 XI, 402.

loaded Odysseus on his departure, in reading how richly Menelaus and Helen did the same for Telemachus returning home we have only to turn to modern stories of Bedouin sheiks and African chiefs, when Africa was none of it white, exercising the like munificence and hospitality. The wandering rhapsodes and minstrels of the Aegean and the shores of Asia extolled these virtues in their audiences for their own profit. They lived on the munificence and hospitality of a lot of pirates, booty and body snatchers, to whom valuables came and from whom they as rapidly went. The arts if not the sciences at their beginning flourished on rapine and we find them turning to heaven for their reward. "It is not my custom," says the swineherd even, "though I might wish the evil, to dishonor a guest, for before Zeus all are stranger guests and beggars."[22] I give to the poor that at least the gods may give to me. Modern man does not flinch before the "do ut des" proposition, but we get a clearer perception of the road we have travelled from primitive times in noting the absence of any uncomfortable allusion to "tainted wealth." Still more primitive and bordering now on magic, of which Homer is surprisingly free in his relations, we find even the slave as a token of respect or fear loath to mention his master's name.[23] Among primitive people we are still familiar with this and the hair and nails as part of modern primitive magic and voodoo. When the swineherd came to kill the pig[24] he cut the hairs from the pig's head and threw them in the fire and showed good sense in not forgetting the dead, for who knows how many ghosts may still be outside of Hades? This he did first and prayed to all the gods. Where magic leaves off and religion begins depends on the piety of the critic. We may infer it was a pretty small pig for a five-year-old from the way it was handled and slaughtered for a party of half a dozen men—and slaughtered on the domestic hearth! Was Homer a city tenderfoot? Very likely, for this sounds like some of his modern critics when they break into bucolics. There has been long discussion among the latter about one or two places in the Odyssey when it apparently speaks of the purple wool shorn from sheep. Did Homer nod here? Or was the original line so worded as to refer to the Tyrrhenian dye afterwards used? No, this time it is the tenderfoot critic. Wool shorn from the wrinkles around an old ram's neck or elsewhere where it is dense and thick, crusted with dirt on the outside and yellow and greasy next the hide, in there between one often does get a purplish tinge to the wool as clipped by the shears. It is a matter of iridescence and vanishes after the fleece is off. Homer may have referred to the dye afterwards used and the line is twisted or he may as a boy have stood close up and watched minutely the clipping of the wool, but the critics surely have never been nearby spectators.

[22] XIV, 56.
[23] XIV, 145, *seq.*
[24] XIV, 420, *seq.*

But not to wander further we must stop to remember that the ancient citizen was far less a tenderfoot among the Homeric Greeks than among us. He was far more deeply versed and immersed in superstitious magic than the light-minded cynic of the cities to-day. Odysseus was famed for his wits and his acquaintance with men and affairs as well as for his religion. Considering in antiquity there was far less difference between the tenderfoot of the tenderloin and the back district rube, between gown and town, between king even and peasant than there is now, the student of ethnology need not be surprised to note that after Odysseus has been cast

ashore on Phaeakia from the frightful peril of the waves, succored by a fair and doubtless curious damsel, after he has penetrated a princely house and has been hospitably entertained, slept there, asked for and has been promised a safe conveyance home wherever it may be over the sea—after all this one may wonder he has still not told his name. Homer, nearer primitive man than we, is apparently so penetrated by this superstition he does not think he is called on for an explanation why Odysseus does not want to tell his name. It was not altogether magic doubtless which induced a stranger in a strange land to hide it. It is just possible he may not be so far from home as to preclude the possibility of his having an enemy who may find him unprotected now by its safeguards, but with primitive man, aside from all this, it is supposed for a man to reveal his name gives any evilly disposed person a handle by which to work his destruction through magic. Homer does not say so, he does not need to, he feels his audience will understand without an explanation.

Notwithstanding this greater levelling of enlightenment as between ranks, as between castes, Homer and Homer's readers were aware of the meaning of civilization. They too were very far from that lack of self-consciousness which is the aim of enlightened people, they were as full of it as the modern city dweller is of his provincialisms when he attempts to display his knowledge of the provinces. Even at the acme of his enlightenment the Greek habitually referred in opprobrious terms to the barbarian from whom he had but lately derived his origin and more recently his civilization. The Homeric Greeks were far enough along to know and define the primitiveness of primitive man, but in the time when Athens was mistress of the seas the contemporaries of Pericles were ever ready to " 'eave a 'arf a brick" at the stranger if he was a barbarian. Reading in Homer the description of the environment of the Cyclops[25] we find they lived in a land where wheat and barley grew wild, from which we are privileged to believe that wild men lived off of wild grain in Homeric days, but wheat and barley had been domesticated probably thousands of years before Homer's time in Egypt and in Asia. The king of the Lastrygians was a cannibal, too, as well as the Cyclops.[26] Cannibalism then probably was not infrequent in the islands and around the shores of the Mediterranean in Homeric times, but that it already excited horror and disgust in Homeric audiences we may conjecture and, as has been said, we thereby perceive too how much nearer Homer was to the realism of primitive life than we and how to this, doubtless, he owes some of the immorality of his verse. For it has been pointed out by many before Professor Scripture[27] that the natural speech expression of the more primitive savages is unconsciously in verse form. That is how, as so many poets report, Goethe and others, their powers come to them. The source of the verse, like the source of essential poetry itself, is in a partial yielding of the self to the demands of the unconscious for expression. Again we see how it is Homer finds[28] nothing unnatural and Odysseus finds it quite a matter of course that the Phaeakians profusely shower costly gifts on him in the spirit which still lingers somewhat with African and Asiatic chiefs.

When we come to the slaughter of the suitors, so outrageous has been their behavior even the modern man feels a return of his savagery and gloats in antici-

[25] IX, 110.
[26] X, 116 to 124.
[27] *Nature*, December 6, 1924.
[28] VIII, 389.

pation of their discomfiture when the old tattered beggar springs to his feet and throwing off his rags reveals himself, the fatal bow in his hand, as the injured Odysseus. Every reader feels it, every critic. The interpolators and scholiasts have nearly ruined this part. They have made it absurd to the point of chilling the readers' glow of sympathy with poet and hero. Killing one hundred and eighteen men makes even a hero, without a machine gun, ridiculous, but it is not this that sickens the modern reader. He has lately made an ovation for the returning hero who has killed thirty-seven. It is not the number, it is the absurdness of the impossible, but beyond this there is something else. The modern man of peace revolted a little at presenting a farm to a man in this age of the world who had the blood of thirty-seven men on his hands and heaved a sigh of relief when he finally disappeared from public view, but we have progressed, or rather we have covered our souls with a little varnish since Homer's day. Deep down, in humiliation after the great war, we acknowledge, lies the bloodthirstiness of the primitive savage, but we have added the varnish. Let us not forget that. We can stand for the moment the slaughter of twenty or thirty men, all the critics seem disposed to believe existed in Homer's draft, but some of the details still sicken us, even cutting it down to this.

Revolting and acutely reminded of the savagery of primitive man, or perhaps sickened to think we too, deep down, have the lust for blood and the joy of seeing the sufferings of our fellow-men who have offended us—we are reminded of both when the hero who mounted willingly and gloriously to the couch of Calypso and enjoyed the favors of Circe hangs the serving women at home to the rafters for adultery and cuts off the nose and ears and feet and hands and genitals of Melanthius and throws them to the dogs.[29] This is war. He had instructed[30] the swineherd to tie up Melanthius by the neck to the rafters so his toes touched the floor that his death might be a lingering one, but now he was dead and that's the way the hero treated the dead body. That is war. Let us thank God after all for the varnish. No poet at least now sings such a tale as that.

We can scarcely bear to see it on the page here crowded in one short paragraph to make up the atmosphere of the Homeric Greeks, the environment of primitive men which lingered around them more obviously, but which lingers with us still. The killing of the wooers was so delicious a morsel the editors and interpolators who followed rolled the episode under their tongues, expanded it and added to it until they made the poor blind old poet ridiculous and his hero killing a hundred and eighteen men with a bow and spear they removed for the moment from human sympathy altogether. They repeated it by removing it to hell and telling it there[31]—it must be confessed a more suitable place. What still further interests us in our study of the social state of primitive man in the Odyssey is Odysseus saying[32] it is best for him to take to the tall timber after he had killed so many of the sons of the most distinguished of the islanders. We get the plain indication of the blood feud requiring, rather lamely, the intervention of Zeus and Athene to wipe it off the slate coming down with the thunder and the lightning.[33]

Miss Harrison has done so much to

29 XXII, 470, 6.
30 XXII, 177.
31 XXIV, 179, *seq.*
32 XXIII, 138–9.
33 XXIV, 539.

collect[34] inferences which connect the classical conception of Zeus' thunder with the bull roarer of primitive man's magic, and her work is so well known it would be gratuitous to more than refer to it here in connection with the numerous thunderings in the Iliad and the Odyssey, but it may be added the primitive awe, still alert in Homer's day, must have made the situations where it is introduced vastly more horrific than is possible for the modern poet or novelist with their finest descriptions of disturbances of the weather. The actual thunderbolts of Zeus found their place with primitive men with more difficulty than the bull-roaring priest found in imitating his thunder, but according to Miss Harrison it seems likely the stone celts dug up in Homeric and classical ages were shown to awe-struck audiences as the missiles of Olympian Jove.

[34] "Themis, a study of the social origins of Greek religion," 1912; "Prolegomena to the study of Greek religion," 1903, Cambridge University Press.

THE CONFLICT BETWEEN SCIENCE AND RELIGION

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THOSE scientists who have been going about "crying, 'Peace, Peace,' when there is no peace" are performing a doubtful service to their mistress. The conflict between science and religion—who can say whether for good or ill?—is most real. Not the paltry conflict recently dramatized for us in an obscure mountain town. Not the conflict, sharp enough but unreal, between Syrian mythological cosmology and the hypothesis of organic evolution. To discuss that is unworthy of the intelligence of mature minds, though unfortunately often necessary.

The real conflict, as the fundamentalist probably dimly senses, lies much deeper. Religion is not, as the scientific compromisers seem to imply it is, something one assumes in church on Sunday and leaves in the vestry with the robes of the choir for the rest of the week. It is a way of life and a philosophy of life. But science also implies a way and a philosophy of life and the two ways are antagonistic. Preachers for unnumbered generations have been telling us that true religion must affect all that we do; but equally it must be affected by all that we do. The interpenetration is complete. How, then, can religion remain indifferent to, or unaltered by, science? Deeply rooted from the beginning in cosmology, how can religion ignore a science which finds in minute telescopic whorls of the Milky Way solar system upon solar system, each dwarfing our own into insignificance?

Think for a moment of the place of prayer in a world of science. It has become fashionable to call a certain type of meditation and self-communion "prayer." I do not mean to doubt the value of such spiritual exercise. It is explicable, though not yet fully explained, on psychological grounds. But this is not prayer. I mean by prayer what truly religious people have always meant by prayer, communion with the Divine. Such prayer is the very heart of religion. "Give us this day our daily bread." Yes, by grace of tractors, self-binding reapers, Minneapolis millers and modern transport. Fifty years ago men could in sober earnest pray for rain. That has passed; we read the weather reports. To-morrow we shall perchance look to the sunspots for our predictions and the day after to-morrow we shall make our own rains. No longer will the Lord make His rains to fall upon the just and the unjust; the rain will fall upon those who have the price. Few are left who invoke prayer for the healing of the sick, still fewer who can see in sickness and in health evidences of God's wrath and mercy. People still pray for strength to withstand tribulation and temptation, but as psychology comes of age as a science, that too becomes impossible. Man's moral life is seen as the inevitable outcome of heredity and environment. For a God displaced by science from the center of the physical universe, there is no shelter in the center of man's soul. To whom, then, shall we pray, and for what?

As science progressively takes possession of our modes of thought, religious modes become increasingly impossible. The end of this process will not come in our day. Scientific discoveries which

can be turned into utilities are quickly adopted, but there is a great lag in time between discoveries which mean new ways of thinking and their penetration of popular consciousness. We are just beginning to reap in common consciousness the fruit of the scientific revolution of Copernicus, Galileo, Kepler and Newton—a revolution nearly four hundred years old. The real fruit of that revolution lies not so much in certain astronomical beliefs as in an altered perspective towards life and natural phenomena. To believe in astrology, to accept comets as portents of coming events, to think of the lightning as the weapon of Jove's or Jehovah's wrath, all this becomes impossible when one has located the earth in its proper place in the choir of heaven.

Evolution in biology is now accepted by cultured people as a matter of course. But only a select few of the world's great intellects have been so thoroughly steeped in the notion that it affects all their thinking. Yet not till evolution passes into the folk-way and into the ordinary vocabulary of the common man will the Darwinian revolution take its place alongside the Copernican. As for relativity, probably no one thinks consistently in its terms. Yet little by little scientific thought is penetrating our logic and the common consciousness. In the end it will inevitably triumph. As it does so, religious ways of thinking recede. Already the "faith of our fathers, living still" has lost much of its power over the lives of men; less and less does it answer to vital needs.

It is a common contention of liberals that this age-long conflict between science and religion is a boundary struggle, a war for the possession of disputed territory. Religion, so the argument runs, has intruded itself into the field proper to science, science has dogmatized about religious matters. There is little doubt that this is a true reading of the history of the conflict between science and *theology*. But as soon as we realize that religion is more than theology, we find that the conflict instead of being eliminated is intensified.

For religion and science both lay claim to disclose truth. Their approach to truth, however, is not merely different; it is antithetical. Religion bases truth upon revelation, whether supernatural or mystic. It endeavors to derive truth from the character of Deity. Science, on the other hand, seeks truth only as it emerges from fact. There are differences of temperament, of course, among scientists as among other men, and from these differences spring more varieties of method than is commonly admitted by those of us who like to talk of the "method of science." The method of the individual scientist may be intuitive, imaginative, deductive or experimental and inductive; it is always empirical, always an effort to learn from and be guided by facts. These two approaches to the shrine of truth can not be reconciled; one or the other must go.

Is this to over-simplify the issue? I think not. A rigorous attempt has indeed been made to divest the concept of religion of all that is accidental and nonessential. Thus most religions have been authoritarian and this has been a source of offense to some scientists. But there have been heretics and mystics in every age who have resisted authority in the true spirit of religion. Authoritarianism is not essential in religion. Again, the scientist sweating for his little bit of truth is apt to feel that the attractiveness of religion for her votaries lies in the easy disclosure of "truth"; that, in short, religion is an escape from reality. But the road of the mystic to his revelation is often long and exceedingly arduous. That the appeal of religion is strong to the weary and the lazy is but an accidental aspect which we must eliminate from the discussion.

Equally we must eliminate non-essential virtues. Religion has so long been the foster-mother of morality that we tend to forget their separate origin and their different natures. The time has come when morality, buttressed by an increasingly scientific ethics, can stand without the support of fostering religion. Nor is social service religion. I believe that we have found the core of religion in its approach to truth. *Religion claims to possess divine truth or rather a divine way to truth. It can not give this up and remain religion. And science demands no less than the unconditional surrender of this claim to truth.* In this fact we find an unreconcilable conflict between science and religion.

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Yet science is not and can not be the whole of life. It must indeed, like any vital human concern, permeate all life. But in the tapestry of daily living, it is but one part. The pattern of that tapestry will be infinitely the richer for the work of science, but it will fall to pieces if, as the other strands rot out, they are not replaced. Men seek not truth only but beauty. Men seek not facts only but their significance and value. Science knows nothing of significance in this sense of the word and is indifferent to values. The realm of values and the realm of facts, though they have concurrent jurisdiction over our acts, can not be intermingled. To be truly scientific is precisely to ignore valuations.

Though science is thus indifferent to the questions of significance and value, living men are not and can not be. Science itself is pursued because it has certain values. Throughout long ages it has been part of the task of religion to raise aloft the standard of values by which men might measure existence and human effort. This must remain when religion shall have perished.

Twenty-five hundred years ago herdsmen prophets in Palestinian deserts had a vision, incomplete and halting, but vivid: God cares, and so man has significance. Something of that vision is needed to-day. The universe is not indifferent! In the face of a cosmic vastness undreamt of by the ancient founders of religion, there are those who dare to assert the significance of man. Human toil and effort and suffering, human happiness and human aspiration after righteousness, these matter. It is these which give meaning to life.

Two very divergent questions will here be raised. Is this not atheistic? And is not this but religion under another name. We should not shrink from the designation, atheistic; belief or disbelief in God matters little. But the attitude we have described seems almost to imply a pantheistic position. To assert that the universe is not indifferent is nearly tantamount to supposing it to be alive. Indeed there seems room for belief in a personal God who shares with man a moral significance.

The second question is less easily answered. It is not wholly a matter of appropriate terms. Were that the case, there would be great practical advantage in abandoning the term religion in the hope of getting rid of the abracadabra of religion, of the endless theological disputes about matters of no present-day moment, of intolerance, of denominationalism and of the other patent evils which, though inessential to religion, adhere like tenacious parasites to their host. To relinquish all claim to be religious would be a cheap price to pay for leaving all these behind.

There is, however, a more fundamental reason for denying that this faith in man's aspirations is religion. Words are not perfect symbols like the x's and y's of algebra to which one may give what meaning one will. We may not lightly undertake to say all that may be meant by such a term, rich in generations of hallowed associations, as re-

ligion. But this seems clear: that religion means now, if it has not always meant, some sort of commerce with the Divine. The fundamental relationship, probably, as has been indicated, is the revelation of truth. Lacking this, a faith no matter how devoutly held as the meaning of life has little right to term itself religion.

The fundamental likeness to religion is not, however, to be overlooked. We have here to do, as in religion, with a faith. Not faith in God, to be sure, but faith in the validity of man's ideals. Such a faith contains within it the values which make religion precious to many forward-looking men. Undoubtedly also, it is religion which has historically promoted these ideals. Even the attitude of mind in which one holds this faith resembles certain religious attitudes.

Its advantage over religion in a world of science lies in its divorce from the claim to possess truth. From this faith in man no truth derives. Lacking this faith, we should not find the facts of life other than they are; they would merely be without significance. It is because this faith abjures all claim to empirical truth that it does not conflict with science.

That is, of course, merely a negative justification of one's faith in the significance of man. Is there no other? No, not if by justification be meant a rational process. Faith is never wholly justifiable by reason. What has reason to do with ultimate values, reason whose function it is to enable us to solve problems and to adjust ourselves to facts? The intellect is not the only side of life. At the heart of life there is an irrational element. I have faith in the nobility of man because I *will* have it so. I have faith in man because to live without it seems to me an incredible paradox.

Then there may be other faiths? Of course! And so long as they deal with values only and not with facts, each is as legitimate as the other. This faith I share with an increasing number of modern men. Will it create institutions, build churches, assemble dogmas? One can not say. But in this faith men will in all literalness as well as figuratively move mountains. In this faith men will live and strive. The source of values, not of truth, the complement of science, not its adversary, here is a faith worthy to take the place left vacant by a religious faith unequal to the conflict with science.

ESTIMATING HUMAN CHARACTER

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THE divining of human character from external appearances has engaged the attention of man from the earliest periods of which we have record down to the present time. The Greek philosopher and guide, Aristotle, became quite encouraged over the matter and wrote a treatise on the subject of physiognomy. He was not the first to give serious attention to this inviting subject nor, by any means, was he the last.

To Theophrastus, the Greek of Eresos, a disciple of Aristotle, belongs the honor of having been the first writer of record to attempt a classification of humanity on the basis of character. At the age of ninety-nine, and, about three hundred years before the birth of Christ, this enterprising gentleman set about to crown his career as a student of human nature by providing posterity with a written record of his observations on the faults and virtues of humanity. But we have his words for it offered in that engaging style which has made his little volume, "The Characters," a classic, to wit:

> I have always been perplexed when I have endeavored to account for the fact, that, among a people, who, like the Greeks, inhabit the same climate, and are reared under the same system of education, there should prevail so great a diversity of manners. You know, my friend, that I have long been an attentive observer of Human Nature: I am now in my ninety-ninth year of my age; and during the course of my life I have conversed familiarly with men of all classes, and of various climes; nor have I neglected closely to watch the actions of individuals—as well the profligate as the virtuous. With these qualifications I have thought myself fitted for the task of describing those habitual peculiarities by which the manners of every one are distinguished. I shall therefore present to your view, in succession, the domestic conduct, and, what may be termed, the besetting practices of various characters. I am willing, my friend Polycles, to believe that a work of this kind may be beneficial to the succeeding generation, who, by consulting these patterns of good and evil, may learn, at once, to avoid what is base, and to assimilate their habits to what is noble; and thus become not unworthy of their virtuous ancestors.[1]

Who could have said better?

A study of the "Characters of Theophrastus" brings in its wake a disappointment, however, in the fact that the untimely death of this thoughtful observer prevented him from completing his task. Only the descriptions of the thirty non-virtuous types were ever finished. The analyses of the virtuous were thus lost to posterity and the world has since been left in doubt as to who Theophrastus really considered them to be.

We can not undertake the task of elaborating the story of the search for the hidden key to human character, for such would necessitate volumes. A few details refuse to be overlooked, however, such as the fact that the Greek writers prior to Aristotle explained differences in temperament by suggesting variations in the compounds of the four elements which they claimed as being the basic constituents of the human body, *i.e.*, earth, air, fire and water. Hippocrates (460–370 B. C.) denied this explanation and satisfied himself, at least, that humanity could be fitted readily into four types, namely, the sanguine, the choleric (bilious), the melancholic, and

[1] "The Characters of Theophrastus." Translated by Francis Howell; London, 1824.

the phlegmatic, depending upon the relative fluid content of the four bodily *humors*—blood, yellow bile, mucus and black bile. The Hippocratic grouping of temperaments as modified a few hundred years later by Galen became classic and can be found to-day with slight variations in many elementary text-books on psychology. The theory of bodily humors has been displaced, however, by the claim of certain modern physiologists that the secretions of the endocrine or ductless glands are the regulating factors in personality.

Vocational guidance through the interpretation of physical structure, one of the favorite money-getting devices of the present-day charlatan, was anticipated by Juan Huarte, a Spaniard, living in the century just following the discovery of America. Huarte petitioned King Philip II, of Spain, for permission to set up machinery designed to offer counsel to the wayward youth of the time. A part of his plea along with his basic thesis will bear repetition.

> Every man is born with a kind of particular disposition; each disposition and each aptitude correspond with a particular form of the head. . . . Thus it seems to me that it is requisite to set apart a number of sagacious and learned men, to examine and investigate into the mental qualifications and capabilities of young persons; in order to oblige them to make a choice of such sciences and professions as would be most in accordance with their intellectual constitutions; and not leave the matter to their own choice or direction. For in general cases, the choice will necessarily be an injudicious one and will induce them to give preference to some line of life which will prove less advantageous and useful to them than if they were under the direction of suitable and qualified counsellors.[2]

The father of most of the modern commercialized systems of character analysis was Johann Kaspar Lavater, a Swiss naturalist, who wrote an elaborate dissertation on "Physiognomy," published in 1787 in four volumes. Although phrenology was practiced by one Senor Rhazes as early as 925 A.D., it was not until Franz Joseph Gall offered his generalizations on phrenology in England during the early part of the nineteenth century that the public really became interested. The hold of his teachings, couched in the imposing terminology of the faculty psychology which was current at the time but which had really been suggested by Plato, upon the lay interest was equally as great as that achieved by the back-water of psycho-analysis during the present decade. The movement spread rapidly, reaching its height in America between 1840 and 1850. Among the group of ardent followers we find many historically famous names, such as Horace Mann and Henry Ward Beecher. Itinerant "professors" with trappings, usually including elaborate charts and models of the head with the areas of some thirty to forty human faculties demarked thereon, along with an occasional human skull, reaped a ready harvest from a gullible public whose members were awed by the profound knowledge concerning the human brain displayed by these "experts" and by the easy authority with which they read hidden secrets from the external contour of the head and face of each unsuspecting subject. Attempts of science to refute the dogmatic claims of these "skull-jugglers" availed little and it was not until some other novel idea caught up the public imagination that the movement died of its own inanition.

In spite of the historical death of the movement, it would not stay dead. The seemingly dead thing convalesced and gave evidence of a strong recovery shortly after the beginning of the present century. Rehashed systems based on the beliefs of the historical writers just mentioned are ever with us. We are invited to buy books which will teach us to judge people at sight. Employment

[2] Bernard Hollander, "In Search of the Soul," E. P. Dutton Co., 1920, p. 132.

managers are told that by using the system they can thereby select suitable men for each and every job in their business organization. One may also, it seems, sensibly choose a life mate by using these schemes of character analysis. Too the salesman is told just how to quietly size up his prospect before reaching the point of requesting a deposit on the first installment.

The proposition of detecting the hidden traits of personality is so extremely inviting and stimulates the imagination to such an extent that a part of the public is ever ready to respond. The proposition has an appeal equal to that of the philosopher's stone of the middle ages or of the "Doctrine of Signatures" of the early years of the modern era or of the alchemist's dream of the twentieth century—synthetic gold. In view of its wide appeal it is not surprising that the response required by the disseminators of this golden key to success, happiness and prosperity is the open pocket book.

Commercialized character analysis continues to be widely exploited. Many claims are made for it and equally strong criticisms are offered against it by practical men. In seeking to determine the truth, one finds further that pseudoscience has made exaggerated claims for the validity of modified forms of phrenology and physiognomy, while science has sought to confound the believers with citations of disproof in theory if not in fact. The resultant disputes, usually accompanied by rising blood pressure, have accomplished little by way of settling the point in question in the mind of the average man. Because of this confusion, the time seemed ripe a few years ago for a series of empirical experiments seeking to determine the validity or non-validity of the claims. Such a program was undertaken by the present writer and Dr. F. B. Knight at the University of Iowa laboratories in 1922.

Some of the most important results of the studies mentioned have been made available by earlier reports.[3] News reports and quotations in popular magazines have represented the results as giving evidence for the conclusion that *there are no external characteristics of the face or head by which the character of a person may be judged.*[4] In strict fairness such a statement is hardly warranted by the results, but it certainly does seem safe to say that *there are no fixed anatomical characteristics of the head or face by which character or personality traits may be estimated with a degree of accuracy such as is demanded by science or in reality by practical needs in every-day life.*

To illustrate one of the most common fallacies in attempting to judge character by external signs we may point out that attempts to judge intelligence by the size or shape of the head seem doomed to failure. Quality counts for more than quantity in brain structure. Extremes in physical structure sometimes give accurate insights into the intellectual quality of an individual, but it does not follow that an extremely small head denotes dullness, while an extremely large head denotes brilliancy of intellect. Extremely small heads are likely to denote low mentality, but so are excessively large heads. Some instances are on record of individuals having a fairly well-shaped head with practically no forebrain and as a result lacking almost entirely in intelligence. Neither may one, by way of further illustration, conclude rightly that a slim, wiry individual is likely to be quick and alert mentally and of an irritable disposition; that the fat man with a full round face is likely to be slow and deliberate mentally but of pleasant dis-

[3] *Journal of Applied Psychology*, June, 1924, Vol. VII, No. 2.

[4] *Hygeia Magazine*, April, 1925; *Literary Digest*, June 20, 1925.

position. Equally incorrect is the assumption that a brunette will become a steadier clerk than the supposedly erratic and temperamental blond. Isolated instances proving all these and similar claims may be found, but in taking large groups of people just as one finds them, exceptions will be found to be quite as numerous as the rule.

The evidence for such denials as those given above grows out of the experiments previously mentioned. The nature and methods of these experiments are described in the following paragraph.

Forty individuals, twenty men and twenty women, were used as subjects in the main experiment in this series. These persons were selected from among members of national sororities and fraternities in a manner designated to get as wide variations in temperament and ability as possible. In a series of measurements, including over one thousand major statistical computations, ratings by a large number of close associates on these men and women were secured covering character and personality traits such as *intelligence, soundness of judgment, frankness, ability to make friends, will-power, leadership, originality* and *impulsiveness*. Ratings by a large group of strangers on the same traits for the same group of subjects were also obtained. A third series of measurements were made following the lines laid down by the self-styled authorities on character analysis. The acquaintances were asked to rate the subjects so that their estimates would reflect the knowledge gained about the subjects through intimate association. The strangers were persons accustomed to employing people, such as business men, school principals, employment managers and others. The strangers were given an opportunity to rate the subjects only on short acquaintance and from external appearances. They were not permitted to interview the subjects. The measurements of the head and face claimed as important by the character analysts were made by means of carefully tested anthropometric instruments, the number of physical indices taken on each subject being somewhat in excess of two hundred.

The outstanding results derived from a critical examination of the ratings and measurements may be stated as follows:

(a) The acquaintances agreed closely with each other in their estimates on all traits listed above, except frankness and ability to make friends. Even on these two the agreement was fair.

(b) The ratings by strangers agreed with each other on all traits except frankness to a rather marked degree.

(c) The ratings by strangers did not agree with those made by the close acquaintances.

(d) The results secured according to the character analysts' recommendations did not agree with each other, nor did they agree with the ratings supplied by either the close associates or the group of strangers.

It seems safe to conclude that there exists only a vague and unimportant relationship between what one may determine from an examination of the fixed features of the head and face and the actual character of the individual. Certain other significant generalizations seem warranted by the data obtained to date:

(a) The relation to the subject of the person passing judgment on his character (friend, enemy, stranger, acquaintance, etc.) causes the estimate to vary widely, depending upon just what the relation happens to be.

(b) When a large group of persons all related to the subject in the same manner pass judgment on him, their estimates are likely to agree closely on some traits but vary on others.

(c) Strangers are more likely to be influenced by external appearances in their general opinions of the subject, but

they are unable to describe accurately just what it is that influences their opinions.

(d) Stranger's valuations of a subject's personal traits are likely to change rapidly as they become better acquainted with the subject.

(e) Individuals differ quite widely in their relative abilities to judge persons from external characteristics. The estimates secured range all the way from twenty per cent. accuracy to as high as seventy-five per cent. accuracy in exceptional cases. Those who are most accurate can not satisfactorily explain their method and in many instances deny that they have any set method.

(f) Training in observational methods of character estimation usually improves the abilities of the poorest judges, but reduces the accuracy of the best judges.

(g) Women are as a group able to form estimates of character from external appearances in just about one half the time taken by men. While men are more deliberative, they are usually just as accurate in their estimates as a group as women.[5]

An examination of all the evidence available seems to indicate that the general rule that may be accepted in any serious attempt to judge other people is that *behavior is a better guide to another's personality and character traits than physical structure.* The term behavior as used here is meant to include all such items as physiological changes in facial expression, gesture, posture, gait, speech, tone of voice, what one says and does in general in reaction to given situations. It must not be hoped that these behavior items will furnish an infallible guide to personality. All that can be said at present is that they may furnish the clues for estimates which may or may not later be verified by further observation of the individual being studied.

What, then, can be said of the future possibilities of judging character from external signs? Science may, after a long series of experiments involving the use of motion pictures and other quicker than eye instruments, be able to give us some solid facts for guidance. Present indications are that the results of brief tests, which depend upon "trying-out" people in given situations, are likely to provide the most reliable and authentic guides to character and personality. Still, there are many people who feel that they must trust to external appearances. To such persons the recommendation best given is to devote attention to observing *behavior* of others in relation to the environmental setting of the individual. It is possible to develop a sense of personal appreciation in somewhat the same manner as we learn to judge distances or learn to understand a language by living with a people who speak it. No system based on fixed features of the head and face is apparently sufficiently accurate to be of any particular aid.

[5] Conclusions (e), (f) and (g) follow citations by F. W. Allport, "Social Psychology," pp. 221–231.

THE EEL IN ANCIENT AND MODERN TIMES

By RALPH C. JACKSON

Of all fishes, both ancient and modern, the eel, Anguilla vulgaris, deserves all the various conjectures and hypotheses which have been recorded in the pages of natural history. No fish ever enjoyed so wide a celebrity. Worshipped in Egypt, esteemed by the epicures of Rome and Greece, recognized by Hippocrates as a therapeutic agent, the life history of the eel baffled the scientific world for over two thousand years.

Eels are found in almost all fresh waters and seas of the temperate and tropical zones. In the United States they inhabit almost all streams of the eastern slope, but were originally wanting on the Pacific coast.

It may reasonably be assumed that no eel ever matures or spawns in fresh water. At this writing no one has ever captured a perfectly ripe female eel and all evidence at our command tends to show that the eel spawns in the sea, and like the Pacific salmon death takes place after spawning.

Eels in their fresh water habitat feed on fish eggs, insect larvae, frogs, and aquatic vegetation. It seems to be the consensus of opinion among fish culturists that the eel is the most voracious of carnivorous fishes. They are most particularly fond of our game fishes, especially trout and salmon. As a rule, eels are night feeders; in the daytime they are generally found in holes or beneath stones.

Meek and Jenkins are of the opinion that female eels grow to a much larger size than males and that the male does not exceed a length of twenty inches.

At certain seasons of the year adolescent eels leave the ponds and rivers and travel over land to enjoy other bodies of water. These migrations generally take place at night during a storm or when the grass is covered with dew. In 1914 the writer found an eel traveling through the wet grass four miles from any lake or pond. The above migratory movement of adolescent eels should not be confused with nuptial migration seawards, which takes place in the autumn.

Eels are divided into two types; yellow eels, which are eels before sex instinct develops, and silver eels, which are eels in their breeding costume. In some bodies of water yellow eels are not found in a well-nourished condition. The head is generally out of proportion, which gives them a weird appearance. In the autumn, the yellow eels take on a silvery coloration as they commence their migration seawards. The belly is a silvery white. The eyes are larger than those of the yellow eels and the gross appearance of the gonads show a change in structure and coloration.

A few years ago, certain Danish investigators working in conjunction with the International Council for the Investigation of the Sea tagged a number of eels to ascertain the number of miles covered during the migratory period. The records of recapture are most interesting. The rate of migration was found to be about ten miles a day. One particular eel covered a distance of seven hundred and fifty miles in ninety-three days. These experiments proved beyond a reasonable doubt the migration was seawards, as all the recaptured eels were found nearer the ocean.

The ancient naturalists knew nothing of the birth of eels. Oppian thought a

gluey substance detached itself from the eel and fell to the bottom and life evolved from spontaneous generation. Aristotle was of the opinion that eels were a solitary race that have neither seed nor offspring. Pliny believed that mature eels rubbed themselves to pieces against the rocks and produced a new brood. Van Helmont, 1635, attributed the birth of eels to the dews of May mornings, while other naturalists thought germination took place in the swim bladder and the intestinal tract. The ovaries of the eel were discovered in 1707 by Sancassini and later described by Valisneri. But it was only in 1873 that the tests of the eel were recognized by the Italian naturalist, Syrski, and shortly after described by Jacoby. The eggs were first discovered by Raffaele in the Gulf of Naples.

For over two thousand years it has been known that sexually developed eels move down the rivers and lakes in the autumn, on their seaward migration and in the early spring young eels or elvers move up the rivers in most countries of Europe. Up to 1896 the elvers or eel fry were the earliest stage of development known to the European naturalists.

In the Proceedings of the Royal Society of London, 1896, Grassi submitted a paper showing that the eel fry stage is preceded by a larval stage and that the little fish known as Leptocephalus are not foreign species, but the larvae of the eel. This minute fish was described by Kaup in 1856 as Leptocephalus brevirostris.

Of all oceanic researches of the twentieth century, the investigation of the eel by E. J. Schmidt, the Danish scientist, stands out preeminently in the annals of biological literature. After eighteen years of profound study, Schmidt elucidated the spawning of the eel. Schmidt found tnat the breeding grounds of the American eel, Anguilla rostrata, lie along the range north of the West Indies and that the breeding grounds of the two species are intermingled in the Atlantic.

During the larval stage the two species are differentiated only under the microscope. It seems to be the opinion that ovulation takes place with the American eel earlier in the season than the European species and as a result of this the American eel reaches the elver or eel fry stage in about a year. With the European eel, metamorphosis does not take place until the third year.

Schmidt (1922) summarized the breeding habits of the eel:

> Spawning commences in early spring, lasting to well on in summer. The tiny larvae 7–15 mm long, float in waterlayers about 200–300 meters from the surface, in a temperature of about 20° C. The larvae grow rapidly during their first months, and in their first summer average about 25 mm in length. They now move up into the uppermost water-layers, the great majority being found between 50 and 25 meters, or at times even at the surface itself. Then they commence their journey towards the shores of Europe, aided by the eastward movement of the surface water itself. During their first summer, they are to be found in the western Atlantic (west of 50 long. W.). By their second summer, they have attained an average length of 50–55 mm, and the bulk are now in the central Atlantic. By the third summer, they have arrived off the coastal banks of Europe, and are now full grown, averaging about 75 mm in length, but still retaining the compressed, leaf-shaped larval form. In the course of the autumn and winter, they undergo the retrograde metamorphosis which gives them their shape as eels and brings them to the elver stage, in which they move into the shores and make their way up rivers and watercourses everywhere.

Courtesy of Swenson & Springer, Photographers, Springfield, Ill.

FIG. 1.—IN THE WAKE OF THE TORNADO

All but the strongest steel structures reduced to a mass of tangled ruins. Peabody Coal Mine No. 9 at West Frankfort.

THE MURPHYSBORO TORNADO[1]

By Professor W. O. BLANCHARD

DEPARTMENT OF GEOLOGY, UNIVERSITY OF ILLINOIS

On March 18, 1925, there passed through eastern Missouri, southern Illinois and western Indiana what press reports have described as the "deadliest tornado of American history." The storm track lay less than two hundred miles south of the University of Illinois, so that the writer, working in cooperation with the Graduate School of the university, was enabled to be on the scene of the disaster within forty-eight hours of the storm's passage. At that time the débris still lay where the elements had strewn it, and the impressions of the storm by those who had witnessed it were still fresh in mind. From the 20th to the 22nd, inclusive, the storm track was crossed and recrossed by the writer at as short intervals as the road conditions permitted, from western Murphysboro to some five miles west of Dale, *i.e.*, for a distance of over fifty miles of the storm's path.

The report which follows is based upon a record of the field observations, upon interviews with a large number of people living in the storm path or its vicinity who had observed the tornado's passage and upon the data furnished by the cooperative observers of the U. S. Weather Bureau and the Washington Daily Weather Maps for March 16 to 19, inclusive. I am particularly glad to acknowledge help given by Professor F. H. Colyer, Carbondale, and Messrs. Clarence J. Root and William E. Barron, meteorologists of the U. S. Weather Bureau, stationed at Springfield and Cairo, respectively.

THE CYCLONE

The low pressure area within which the tornadoes of March 18 occurred probably originated in the region of the Gulf of Alaska, on March 13.[2] It appeared first on the Washington Daily Weather Map on March 16 near Calgary, Alberta. Its subsequent path, as well as the points reached at the end of each twelve-hour period, is shown in Figure 2.

Sweeping southward with increasing intensity, it reached the Oklahoma-Texas boundary on the evening of March 17. Here it made a right-angled turn to the north. On the morning of March 18, it reached a point just beyond Fort Smith, Arkansas, and during the following twelve hours there developed within it a series of five tornadoes. The path of the Low during that day led through southeastern Missouri, southern Illinois and western Indiana. Passing up the Ohio, it left the continent via the St. Lawrence Valley.

The part of the cyclone track mapped in Fig. 2 has a length of approximately 3,361 miles, which it traversed in eighty-four hours or at an average rate of forty miles per hour. The maximum rate of advance for any twelve-hour period was between Missoula, Montana, and Leadville, Colorado, where it reached a speed

[1] An investigation conducted under the auspices of the Graduate School of the University of Illinois, by whose aid the field observations were made possible.

[2] H. J. Cox, meteorologist, U. S. Weather Bureau, Chicago, Ill., in private communication to the writer under date of April 8, 1925.

PROGRESS OF THE CYCLONE[3]

Date	Hour	City near center of Low	Progress in past twelve hours (miles)	Rate of advance in last twelve hours	Barometric pressure reduced to sea level
Mar. 16,	7 A. M.	Calgary, Alberta	. .	.. .	29.62
" 16,	7 P. M.	Missoula, Mont.	346	-28.8	
" 17,	7 A. M.	Leadville, Colo.	650	-54.2	29.62 (Denver)
" 17,	7 P. M.	Altus, Okla.	520	-43.3	
" 18,	7 A. M.	Bentonville, Ark.	365	-30.4	29.62 (Ft. Smith)
" 18,	7 P. M.	Terre Haute, Ind.	425	-35.4	. ..
" 19,	7 A. M.	Rochester, N. Y.	530	-44.2	29.5 (Buffalo)
" 19,	7 P. M.	Father Point, Quebec	525	43.75	
		Total distance	3361	Av. 40.0	

of 54.2 miles per hour. During the twelve-hour period in which the tornadoes developed, the cyclone advanced at an average rate of 35.4 miles per hour.

By the evening of the 17th, the low pressure area had taken the form of a huge trough reaching from Ontario to Mexico. The isobars about the Low for 7 A. M., Wednesday, March 18, are reproduced in Fig. 2 from the Washington Daily Weather Map for that day. They show a striking resemblance in form to that of the generalized type favorable for the development of squalls and tornadoes, as shown in Fig. 3.[4] The

[3] Data from Washington Daily Weather Maps for the days indicated.

[4] R. DeC. Ward, "Tornadoes of the United States," *Jour.* Royal Meteorological Society, 43: 1917: 324, Fig. 5.

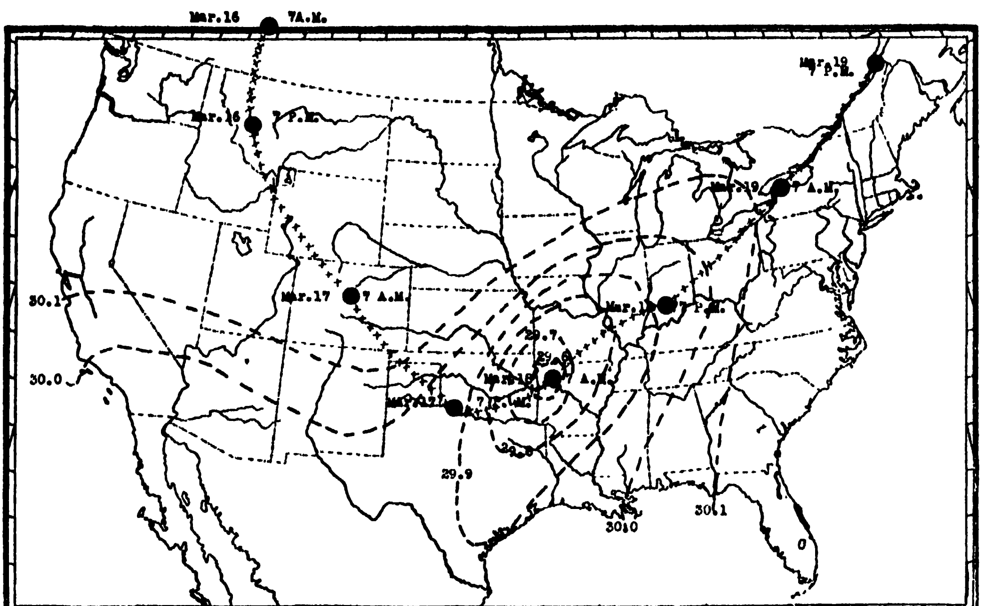

FIG. 2.—PATH OF THE LOW PRESSURE AREA
IN WHICH DEVELOPED THE TORNADOES OF MARCH 18, 1925. ISOBARS ARE DRAWN ABOUT THE LOW FOR MARCH 18, 7 A. M., CENTRAL STANDARD TIME.

V-shaped prolongation to the south, the axis of which represents the meeting place of the warm, moist winds from off the gulf, with the cold, dry winds from the north, is very well developed.

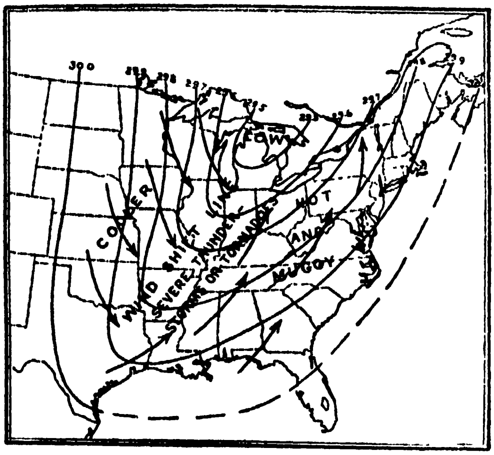

FIG. 3.—GENERALIZED LOW SHOWING CONDITIONS FAVORABLE FOR SQUALLS AND TORNADOES. COURTESY OF R. DEC. WARD.

The records as reported[5] by observers along either margin of the tornado path confirm the existence of this condition. A study of the data given below shows a difference in temperatures, both maximum and minimum, between the stations north and those south of the path, considerably greater than is to be accounted for by the difference in their latitudinal positions.

[5] Private communications to the writer from U. S. cooperative observers at the places named in the table.

THE MURPHYSBORO TORNADO

Object of Field Observations:

The field investigation was intended to establish as far as possible facts bearing upon the following:

(1) The path of the storm, its exact location, dimensions and continuity of earth contact.
(2) Movements, both progressive and rotational, their direction, velocity and the time required for the storm to traverse a given point in the path.
(3) Evidence of low atmospheric pressures, the bursting of buildings and strong updraft capable of lifting heavy objects.
(4) The weather conditions preceding, during and following th storm and the appearance of th storm itself.
(5) Damage done in different por tions of the path, the effect of re lief features and the relation o building construction to the pro tection of life and property.

The Storm Track:

The path of the tornado was unusua in many respects. As shown in Fig. 4

WEATHER OBSERVATIONS ADJACENT TO TORNADO BELT, MARCH 18, 1925

Points North of Tornado Path

	Sparta	DuQuoin	McLeansboro	Mt. Carme
Max. temperature	61	65	64	60
Min. "	43	42	45	46
Wind direction	SE	NW	SW	NW
Sky	Cloudy	Cloudy	Cloudy	Cloudy
Precip. in inches	.16	.77	.	.40

Points South of Tornado Path

	Carbondale	Harrisburg	Carmi
Max. temperature	69	74	..
Min. "	48	49	..
Wind direction	SW	SW	....
Sky	Cloudy	Pt cloudy	Cloudy
Precip. in inches	.82	. .	1.02

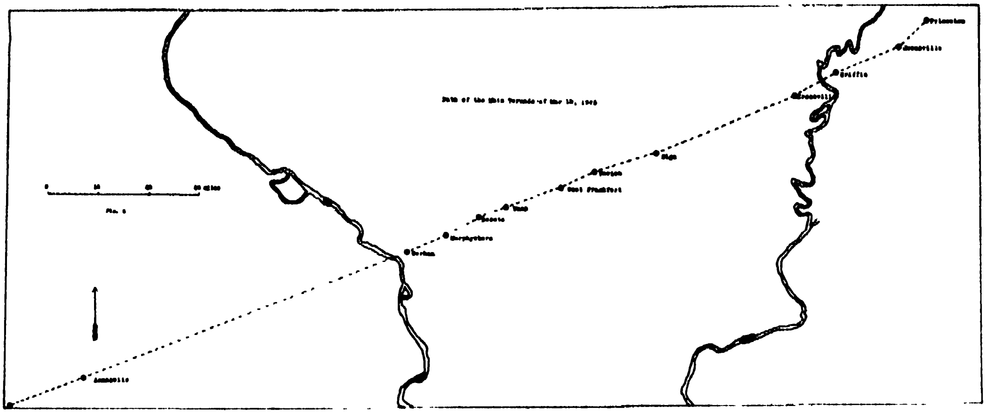

FIG. 4.—MAP OF TRACK OF THE TORNADO

it maintained a direction which varied but little throughout its entire extent. In Illinois it lay about 21° north of east. Though but slightly over two thirds of the length of the Mattoon tornado of 1917, it is about ten times as long as the average for this section. Throughout its entire length of about 220 miles, it never severed its contact with the earth. The total width of the path in the portion observed, furthermore, was maintained practically constant at about three fourths of a mile; that in which everything was practically all destroyed, at from one half to two thirds of the total. The breadth in Missouri is reported as being one fourth mile; at the other end of the path, it narrowed to that width only after the storm had reached a point one and one half miles beyond Princeton, Ind.[6] For over one hundred miles of the path, the width was maintained fairly uniform at about three fourths of a mile. The total area affected exceeded one hundred square miles, of which about fifty were completely devastated.

Eastward Progress of the Tornado:

The speed at which the storm swept eastward was unusually rapid. The actual velocity was determined by checking the time of the storm's arrival at the several cities and villages along the path. Since the route between towns was essentially an airline, the exactness with which the velocity could be computed depended upon the accuracy of the reports of the storm's arrival. Clocks which went down when the storm struck[7] or which stopped when the walls to which they were attached rocked and swayed[8] were sought for and their record kept if the owner could verify their accuracy. Office managers,[9] railway men and others who would be likely to know the time were sought and their reports checked against each other. The table on page 439 gives the data secured for points between Gorham, Illinois, and Griffin, Indiana.

The average forward movement is thus seen to have been almost a mile a minute. This was about 50 per cent. greater than in the case of the Mattoon storm in 1917.

Duration of the Storm at Any One Point:

Estimates of the actual duration of the storm at any one point were difficult to get from survivors. This was to be ex-

6 C. J. Root, in a private communication to the writer under date of March 30, 1925.

7 Murphysboro.

8 Bush Y. M. C. A.

9 Orient Mine No. 2, West Frankfort.

RECORD OF FORWARD PROGRESS OF THE TORNADO FROM GORHAM, ILL., TO GRIFFIN, IND.

Place	Arrival	Airline distance in miles from preceding point	Speed in miles per hour
Gorham	2:25[10]		
Murphysboro	2:32	8.5	73.0
Bush . .	2:47	13.4	53.6
W. Frankfort	3:00	11.8	54.5
Parish	3:07	7.0	60.0
Griffin .	4:04[10]	55.0	58.0

Total time, 1 hour 30 min. for 95.7 miles. Av., 58.0.

pected, of course, for in the midst of such a storm seconds may well seem like minutes. However, the period of duration may be computed, since we know the diameter of the whirl and the velocity of forward progress. Since the width of the path, and, therefore, of the whirl was about three fourths of a mile, while the forward velocity was about a mile a minute, it would take about three fourths of a minute for the storm to pass a given point. Estimates by observers ran as high as fifteen minutes.

Criteria for determining Wind Direction:

The wind directions at various points in the storm path were shown by the direction of fallen materials. Small wooded tracts or open fields strewn with débris were selected for study in preference to shade trees along city streets. Unsymmetrical trees or those likely to be deflected in their fall by telephone wires or whose roots may have been cut on one side for sidewalk or sewer construction, were passed over as unsatisfactory evidence. The woodlot just west of the high school at the western margin of Murphysboro and the open fields of corn stubble strewn with strips of siding west of the M. & O. tracks in the same city, the open fields and scattered trees of "The Camp" north of Bush, were types of places selected for observations.

Rotational Movement:

That the chief movement of the air in this storm was rotational and therefore tornadic, there is no question.- Eyewitnesses and the evidence offered by damaged buildings and twisted trees furnished abundant proof. During the course of an examination of such evidence one came occasionally upon a case where the rotation seemed to have been clockwise, *i.e.*, contrary to the well-established law for rotating storms in the northern hemisphere.

FIG. 5.—CHURCH

FOUR AND ONE HALF MILES WEST OF DALE APPARENTLY ROTATED CLOCKWISE.

Fig. 5 shows a church which faces east and it will be seen that the rear end has been moved some fifteen feet to the north; the front end only five or six feet in the same direction. The building is located on the extreme southern margin of the storm track. Fig. 6 shows a frame house originally resting upon cement blocks. The structure has been turned 90°, the wing now facing east (to the left) was formerly nearest the point where the camera stood. Both buildings

[10] The time at Gorham and Griffin was reported in a private communication to the writer by C. Root, meteorologist, Springfield, Illinois, under date of March 30, 1925.

FIG. 6.—HOUSE AT NEPERS CORNERS
THREE AND ONE HALF MILES NORTHEAST OF DALE. ROTATION APPARENTLY 90 DEGREES IN CLOCKWISE DIRECTION.

have been turned in a *clockwise* direction. Again in Fig. 7 there is shown a locust tree located near Parrish in which the twisting of the top would seem to have been the effect of a clockwise-moving wind. Though at first somewhat disconcerting, it does not seem at all unreasonable to find buildings moved as indicated. Such results may very well be due to differences in the rigidity with

FIG. 7.—LOCUST TREE
APPARENTLY TWISTED IN A CLOCKWISE DIRECTION. THE GRAIN WAS NOT STRAIGHT BUT SPIRALLY ARRANGED.

which the frame superstructure is fastened to the foundation. If, for example, the front portion of the church building had been rather firmly attached, a strong south or southeast wind in the tornado could easily turn it as shown. It will be noted that the whole building was moved north. The wind as shown by the fallen trees about Fig. 6 was from the north. If the northwest corner (on the right) was fastened rather securely,

FIG. 8.—HARD MAPLE
ON 22ND AND SPRUCE STREET, MURPHYSBORO, TWISTED COUNTERCLOCKWISE. THE GRAIN IS STRAIGHT.

the movement would be as shown. An extreme case illustrating the same point was found in Murphysboro, where a filling station had been rotated clockwise, the building being turned upon the concrete tank in one corner which acted as a pivot.

In the case of the tree in Fig. 7, it would seem entirely possible to produce the results shown if the original grain of the wood formed a spiral. A careful examination showed this to be the case, the

FIG. 9.—BUILDING ROTATED COUNTER-CLOCKWISE, MURPHYSBORO.

FIG. 11.—HOME OF A. CRISP, PARRISH, ILL. A 2 x 8 TIMBER DRIVEN THROUGH STUDDING NEAR CORNER.

winding being clockwise, as may be seen in the upper half of the trunk. With such texture to start with, the splintered top blown over by a straight wind would appear to have been twisted in the direction of the grain. It should be remembered that the number of such cases was very limited, those whose movements were normal being vastly greater. The

FIG. 10.—RESIDENCE ON EIGHTH STREET, MURPHYSBORO, SHOWING EFFECT OF FLYING MISSILES.

maple shown in Fig. 8 and the building in Fig. 9, for example, show a normal twisting.

The actual rotational velocity of the wind can only be estimated from the effects seen. Sticks and splinters without number were driven through pine siding of buildings. Fig. 10 is typical of walls left standing in the storm path. At West Frankfort a piece of 2 x 4 was

driven through the side of a coal car, fitting as tightly as though shaped by a cabinet maker. At the home of A. Crisp, Parrish, a piece of 2 x 8 yellow pine was driven through the siding, passing completely through a 2 x 4 oak studding and the end lodged against a second studding, as shown in Fig. 11. Straws driven into trees were reported near Crossville.[11]

The general wind direction and the location of the wind shift line are shown in Fig. 12. The arrows show the direction of the wind. It will be seen that the wind shift line lies about one fifth of the distance from the north margin of the path. The change from northwest to southeast winds along the line was very sharply marked—less than a block in width as a rule.

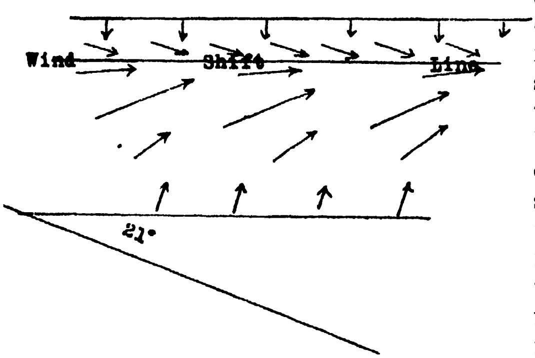

FIG. 12.—WIND DIRECTIONS IN A CROSS SECTION OF THE STORM TRACK AT MURPHYSBORO.

The great majority of the trees lay toward the northeast as shown. This was to be expected, of course, since this was the direction of the storm's progress. The velocity of the wind at any point in the path was the resultant of the rotational and the translatory movements. The velocity of the latter has been shown above to be about fifty-eight miles per hour. On the northern margin of the path then, the resultant would be the rotational velocity reduced by fifty-eight miles per hour; on the southern border it would be the rotational speed increased by a like amount. We have then not only four fifths of the width of the path south of the wind shift line but a velocity there which, at the extreme edges, should be 116 miles an hour greater than in the portion to the north. It is little wonder, then, that the main mass of débris was distributed as though blown from the southwest.

Low Pressure in the Tornado:

The extent to which the atmospheric pressure was reduced in the center of the tornado is, of course, not known. A barogram from an instrument one and one fourth miles south of the center of the storm track at West Frankfort is shown in Fig. 13.[12] The passage of the cyclone or Low across West Frankfort is shown by the broad V-shaped depression as occurring between 9:30 and some time past midnight of Wednesday, March 18. At 2:54, however, the needle dropped .23 inch, rising immediately the same distance and then rose gradually as the cyclone moved by. The drop of .23 inch recorded the passage of the tornado to the north. The record is of interest not only as showing a marked decrease in pressure entirely outside of the tornado path but as showing that the tornado at that place occurred simultaneously with the passage of the Cyclonic Low though the latter was probably centered north of the tornado. In most cases tornadoes have developed to the southeast rather than directly south of the center of the Low. The barograph at the Carbondale Normal, seven miles south of the path, showed no marked change which could be attributed to the storm.[13]

[11] Root, C. J., and Barron, W. E., "The Tri-State Tornado of March 18, 1925," Climatological Data, Ill. Section, March, 1925, p. 12d.

[12] Supplied the writer by Mr. J. E. Jones, of the Old Ben Corporation, West Frankfort, in private communication of March, 1925.

[13] Reported to the writer by Mr. F. H. Colyer, cooperative observer, U. S. Weather Bureau, Carbondale, Illinois.

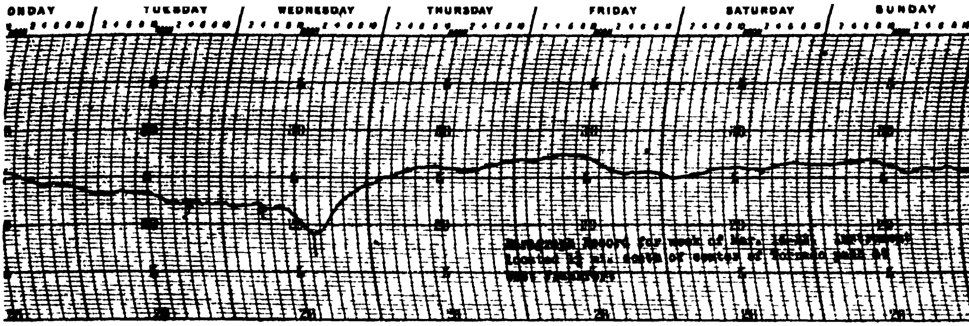

FIG. 13

THIS RECORD IS A TRACING FROM THE ORIGINAL LOANED THE WRITER BY MR. J. E. JONES, OLD BEN CORPORATION, WEST FRANKFORT, ILL. THE CLOCK STOPPED ON TUESDAY PRECEDING THE STORM FOR 12 HOURS (THE PORTION OF THE CURVE BETWEEN THE ARROW). THE INSTRUMENT, ACCORDING TO THE METEOROLOGIST OF THE U. S. WEATHER BUREAU AT CAIRO* WAS APPARENTLY RECORDING ABOUT .2 INCH TOO LOW. AS CORRECTED THE NEEDLE SHOWED A DECREASE IN PRESSURE DUE TO THE PASSAGE OF THE LOW TO 29.1 INCHES; THE TORNADO PRODUCED A FURTHER REDUCTION TO 28.87 INCHES. HOWEVER, THIS DOES NOT AFFECT THE FORM OF THE BAROGRAM.

* W. E. Barron in private communication to the writer under date of May 4, 1925.

FIG. 14.--RESIDENCE AT MURPHYSBORO SHOWING PASSAGE OF CYCLONE AND TORNADO

Evidences of the low pressure in the form of exploded buildings were difficult to find. In many cases at Murphysboro, at least three walls identified as belonging to the same building had fallen outward. Fig. 14 shows a residence at 1912 Walnut Street, Murphysboro, in which the east gable-end, including the studding above the window, had apparently burst outward. The building appeared to be otherwise intact, except for windows and doors. Other types of evidence were not lacking. A shot-firer at Orient No. 2 said the forced ventilation system was non-effective while the storm passed. Many observers reported great difficulty in breathing during the worst of the storm. A cistern at DeSota, which had held eight feet of water, was said to have had but half that depth after the storm passed.[14] The disappearance of the house described by F. M. Hewitt, on page nineteen, was undoubtedly due to explosive violence.

[14] Reported by F. H. Colyer, Carbondale, in a communication dated April 29, 1925.

Appearance of the Storm:

The description of the tornado's approach by eye-witnesses varied with the position of the observer, the time of the observation and his mental state at the time. The rapid approach of such a huge death-dealing phenomenon provides conditions hardly conducive to calm and careful observation.

Of the many descriptions recounted to the writer, one seems particularly worth repeating. The observer, F. M. Hewitt, of Carbondale, occupied a vantage point at DeSota, directly in the path of the storm, which he first noticed when about three fourths of a mile to the southwest. He described the sky above the tornado as a seething boiling mass of clouds whose color changed constantly. From the upper portion, there came a roaring noise as of many trains. So definite seemed the source of the noise that it called for his remark to his two companions that the sound all seemed to "come from this upper part." Below this agitated, baggy-shaped mass of cloud, there was a tapering dark cloud mass reaching earthward. Lighter clouds flanked this dark mass upon either side. He estimated the width of the dark pendent portion as one fourth mile[15] where it touched the earth. As they watched the approaching storm in the growing darkness, a lightning flash showed a small house which a moment later disappeared as though dynamited. The three observers took refuge in a house which, when the storm struck, was dissipated, except a partition against which one of the party was standing. He was untouched, the other two were carried with the débris and one severely hurt. Mr. Hewitt was blown into the street, where he clung to a post until the storm had passed. He reported extreme difficulty in breathing for a period estimated at about twenty-five seconds.

Some of those who were in the storm path said they could distinguish no funnel-shaped cloud, others saw one or, in some cases, two which seemed to draw together from north and south and coalesce.

Thunder as of an approaching thunderstorm was heard, rain and hail fell, though not in excessive quantities. The feature which dominated the whole situation was the terrific wind filled with flying débris. A few rods to either side of the storm path, the most fragile structures, *e.g.*, huge signboards, were untouched.

It seems quite clear, from the numerous reports, that there was nothing of the dangling rope-like form suspended from the cloud canopy, such as is often seen to the west of the Mississippi. The dark mass reaching the earth was wider and much less definite in outline. The suggestion of C. J. Root[16] that the funnel cloud was so low as to resemble an inverted truncated-cone would seem to be an excellent one.

Tornado Prediction:

Tornadoes are often spoken of as "erratic," which means essentially that we do not thoroughly understand the detailed conditions giving rise to them or which control their action. In spite of their success in forecasting the normal changes associated with the passage of Highs and Lows, the U. S. Weather Bureau has never attempted to predict tornadoes. We know from a study of the records of such storms their areal and seasonal distribution, their association with the type of Low shown in Fig. 2 and their general direction of progress.

Their relatively rare occurrence, their limited period of existence, the restricted area covered and the conditions which control the direction taken, to say nothing of the reason why in some cases

15 As indicated above, the path of essentially total destruction was two or three times the width.

16 Root, C. J., and Barron, W. E., "The Tri-State Tornado of March 18, 1925," Illinois Climatological Data, March, 1925.

they skip about, lifting here and dipping to earth there[17]—all these are still problems remaining unsolved.

From a description of the tornado of March 18, it would seem comparatively simple to have sent word from the section first struck to the communities farther east. However, this tornado was unusual in its regularity. If all such storms moved as this one did in a fairly straight line for a long distance, keeping contact with the earth, maintaining a fairly uniform width and moving at a comparatively uniform rate, the problem of sending warnings ahead would be fairly easy. It seems, to the writer, that while we shall have to wait for more information before attempting a forecast, some system of warnings might be arranged to be sent after the storm had once appeared. If people had been on the watch they could easily have moved to the one side of the danger zone in three minutes, even if in the center of one of such unusual width as the Murphysboro storm.

Relation of Tornadoes to Building Construction and Insurance:

After a study of over five thousand tornado records, Lieutenant Finley concluded that it was useless to construct a building with the idea of making it strong enough to withstand a tornado. If one lived in a region frequented by such storms he advised the erection of tornado-caves or cellars and the spreading of the risk or loss of building by[18] insurance.

A report on this subject is now being prepared by a group of engineers from the faculty of the University of Illinois as a result of their study of the buildings in the path of the tornado of March 18. One of their number has stated as a result of preliminary computations that he believed buildings could be constructed to withstand such storms at a very small extra initial outlay. The bearing of such a problem upon the question of construction for protection of life, especially in public buildings such as schools, and the relation of such construction to insurance costs is obvious.

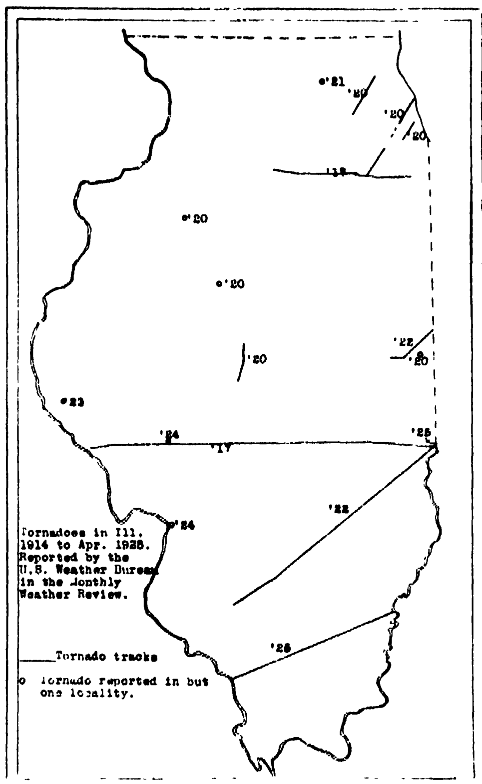

FIG. 15.—MAP OF TORNADO TRACKS IN ILLINOIS, 1914–APRIL, 1925.

An examination of the damaged buildings should show the necessity of having the floors forming the ceiling for the basement strong enough to bear the pressure of falling walls, thus serving as substitute for storm cellars. A remarkably large proportion of the buildings

[17] Note the tornado track through Will and Cook counties made in 1920. It seems quite probable that the disturbances in these two counties belong to the same tornado which lifted as it crossed Dupage County. See Fig. 15.

[18] Finley, J. P., "Tornadoes," *The Insurance Monitor*, New York, 1887.

destroyed had no basements. Resting as many of them did upon cement or wooden blocks, the wind had ample opportunity to get under the buildings and move them bodily. "The Camp," north of Bush, consisted of such light buildings. A glance at Fig. 10 shows the danger to which a person is exposed in the open spaces of a city or village.[19]

Fig. 15 is suggestive to those interested in tornado insurance. It will be noted that while the northern half of the state had about twice as many tornadoes as the southern, the latter because of the longer tracks have a much higher tornado liability. The bearing upon insurance risks and rates is obvious. Another aspect of interest to insurance companies is suggested by the map. In view of the general direction taken by tornadoes it would seem highly desirable for local companies insuring against tornado damage to spread their risks in a northwest-southeast direction rather than in a belt at right angles to this. Such a company confining its business, say to Jackson, Franklin and Hamilton counties, might be seriously embarrassed if not rendered bankrupt by such a storm as occurred March 18. It would seem highly desirable to map in great detail the frequency of tornado storms on the basis of the area devastated for as long as period as possible, as a basis for storm insurance.

[19] It is reported that a workman returning along the railway tracks from West Frankfort was overtaken by the tornado and took refuge behind one of the heavy plank posts used as "whistle" signals. Lying flat, face downward and clinging to the post he escaped serious injury, but his fingers exposed on the windward side were battered and skinned by flying missiles. Another less fortunate pedestrian took refuge behind the railway embankment, clinging to the rails to prevent his being blown away. Flying débris struck him, however, inflicting fatal wounds.

RADIO TALKS ON SCIENCE[1]

THE STORY OF THE NORTHERN ROCKIES[2]

By GEORGE R. MANSFIELD

UNITED STATES GEOLOGICAL SURVEY, WASHINGTON, D. C.

To him who in the love of Nature holds
Communion with her visible forms, she speaks
A various language.

THESE beautiful words of Bryant appeal with special force to the geologist because his business is to commune with the visible forms of nature and to try to understand her language. One of the most fascinating stories that she has to tell is to be read in mountain regions, where the rocks may be better seen than in many other places and where the exhilaration of living and climbing adds zest to pleasurable attempts at unravelling her many mysteries. Such efforts have a practical value for mankind, for in learning to read the story of the rocks much light is thrown upon the formation and distribution of valuable mineral deposits, useful supplies of water, or commercial pools of oil or gas. Ground is laid for the hope that we may in time abate the terrors and losses of earthquakes and of volcanic and other disasters of natural origin.

The story of mountain ranges like those of the Northern Rockies is not merely a record of a single great accident or convulsion of nature, or even of a group of such events. It begins in the remote past before there were any mountains at all in that region and continues into the future to a time when the mountains as we know them must be gradually reduced to lower hills or even be completely worn away. It is like a great and slow-moving picture, which we may look at for a time, but we are late in arriving at the theater and have to leave early. Although we actually see but a small part of the picture, we may from the evidence presented supply in imagination the parts that have gone before as well as those yet to come and thus gain a fairly accurate idea of the whole.

When we enter the Northern Rockies we are at once impressed by the beauty of their scenery. Here we note rugged cliffs of massive rock; there the valley sides retreat in gentle wooded slopes; here a stream tumbles noisily in beautiful cascades; there it winds slowly among brushy banks or in grassy meadows. Perhaps we catch the glint of snow on some of the upper peaks or see a glacier nestling in the shelter of a lofty ridge. Clouds hover in the sky above and their shadows chase each other among the valleys or are reflected from mirrored lakes. Their cooling shade refreshes the traveller after the heat and glare of the noon-day sun. These elements of the scenery are pages of the story we are following, so we must examine them more closely.

The rock ledges that first attracted our attention may be arranged in layers or beds, or may be crystalline or fine textured without noticeable bedding. The bedded rocks or strata are particularly interesting because in many places they preserve the remains of animals or plants; they may show current or ripple markings indicative of shallow water or of wave action; or they may contain cracks, footprints, or rain drop impressions like those now found in half-dried

[1] Broadcast from Station WRC, Washington, D. C., under the auspices of the National Research Council and Science Service and the direction of A. L. Barrows.

[2] Published by permission of the acting director of the Geological Survey.

mud flats. Elsewhere they consist of sands like those that now form dunes along our coasts or in desert areas; or contain gravels like those in stream beds. The presence of shells of sea animals in strata that are now thousands of feet above sea level shows that the mountains were built up at a place where once the sea had been. Similarly beds of coal or of cemented gravels in the same region show that the sea gave place to swamps or lowlands. Indeed as we examine the strata in detail we read in the successive rock layers that the sea advanced and retreated over this ground many times and that there were intervals when deserts, swamps, rivers, or even fresh water lakes occupied the country instead. As the geologist measures the thickness of the beds exposed to view he finds that the total runs into many thousands of feet. For example, in southeastern Idaho the thickness of the sands, muds and oozes now consolidated into rocks is about 46,000 feet, or more than eight miles. Since these beds were all laid down on what was then the sea bottom, or the surface, it follows that there must have been a progressive sinking of the ground while deposition was going on else these areas could not have continued to receive from neighboring lands such thick masses of sediments.

The rock layers are no longer nearly flat, as they doubtless were when first formed, but are now bent, twisted and broken in many places, thus furnishing evidence of former tremendous forces acting horizontally within the crust of the earth. Acquaintance with these mountains and with other regions brings out the fact that the earth is gradually shrinking in volume and that its outer crust is constantly being squeezed like the skin of an apple drying up. At repeated intervals the accumulated pressure has been too great for the rocks to resist and they have been crumpled into mountain chains in different parts of the earth. Mountain-building may therefore be said to be one of nature's habits. The favorite places for such events to happen have always been where muds and sands and other sediments have been laid down in greatest thickness. It is believed that at such places the crust is progressively weakened as the sediments gather and that the position and distribution of these strata in some way determine where and how the mountain-building forces shall act.

A contributing element in the process is undoubtedly the intrusion of great masses of molten rock, which have later crystallized on cooling underneath or within the strata. These intrusions have acted in some places like great hydraulic jacks in moving parts of the earth's crust.

Each movement or break in the rocks produces jars or tremors that we call earthquakes, so that it is natural that such disturbances should be associated largely with mountain regions. In fact their relative frequency is an index to the rate of growth of mountain chains. Thus the greater number of earthquakes in the Pacific Coast Ranges than in the Northern Rocky Mountains indicates a more rapid rate of growth in the former mountain group. On the other hand, the Montana earthquakes of 1925 demonstrated that mountain-building activity in that region has not wholly ceased. People are now living, traveling and carrying on the business of life in the coast region of California apparently unmindful of the fact that mountains are growing beneath their feet. Indeed the work of building mountains goes on so slowly that the average man in his lifetime may recognize few changes. Although careful instrumental measurements in the Coast Ranges have shown that crustal movements are in progress there, many centuries must elapse before the general appearance of the country will be much different from what it is now. Yet it is probable that the present rate of growth of the Coast Ranges is as fast as that of any of the mountain ranges that have formed in the past.

The crumpling of the strata into folds has been accompanied in the Northern Rockies by breaks in which great masses of folded rocks have been shoved bodily eastward over other masses, like one great ice cake upon another, for distances as great as 25 or 30 miles and along fronts ranging up to more than 250 miles in length from south to north. Such great breaks are called overthrusts. Individual overthrusts have been known in different parts of the Northern Rockies for many years both in the United States and in Canada. It is now being realized that these overthrusts are related to each other and that the earth's crust in the Northern Rockies has been piled in great slices with astounding horizontal movement and with total length probably approximating 1,000 miles.

It has long been known that the earth's crust is in a state of comparative balance, so that when any part of its surface receives a great load it tends to sink, while by some compensating change within the body of the earth neighboring areas tend to rise, much as if the earth's surface were a great pair of scales. It is therefore evident that when enormous masses of rock are piled up on the earth's surface by mountain-building agencies, the areas receiving such loads must tend to sink until the balance is restored. Thus the Northern Rockies with their folded and broken strata rising several thousand feet above the plains on the east must have overloaded the earth's crust when they were being piled up and must have sunk with the crust a certain distance during the restoration of balance, and hence are not so high as mountain-building alone would have made them.

Thus far we have centered our attention on the rocks, but the streams, snows and glaciers, which are parts of our mountain scenery, and the changes in temperature which we experience there have their part in the story. Their combined action is to loosen and remove pieces of rock, ranging in size from the finest flour-like grains to great boulders weighing several tons or even to landslides comprising thousands or millions of tons of rock debris. This material slides down by its own weight or is washed into the streams and is gradually removed from the mountain region altogether. Much is also carried away in solution. These processes, which we summarize under the terms weathering and erosion, are important factors in controlling the height of mountains.

No sooner do infant mountains rear their heads above sea level than they are attacked by winds, rains and other atmospheric agencies which tend to wear them down. The height which the mountains attain, therefore, gives a measure of the relative rapidity of work of the mountain-building and erosional forces. In the earlier stages when the agencies within the earth are more active the mountains increase in height. When these agencies slacken or cease, erosion continues and the mountains are slowly but surely reduced to lowlands. In the Pacific Coast ranges already mentioned growth is more active than erosion. The Northern Rockies are probably in mid career, with erosion perhaps slightly gaining. The Appalachians on the other hand are in the declining stage, when growth has practically ceased but erosion is still vigorous.

A mountain region that has passed through one long period of growth and decline in the manner just outlined may by renewal of activity within the earth be slowly lifted up again, and started on another similar course. Most mountain regions have had this experience and some of them have had it several times. Thus the history of a mountain region, which may appear simple in its broader outlines, becomes complex when it is studied in detail.

The Northern Rocky Mountains have been largely shaped by the sculpturing action of streams and glaciers, but the erosion has been guided by structure,

that is, its action has been selective among harder and softer rocks. The rocks that comprise the great overthrust blocks are generally more massive and more firmly consolidated than those of much of the over-ridden country. The overthrust blocks therefore in many places serve as protective cappings for weaker rocks that are elsewhere worn down or removed. Valleys that are deep enough to cut into the weaker rocks below the cappings afford opportunities for the geologist to identify the overthrusts, where the two kinds of rock are in contact, and to follow their courses across country. A particularly good place to see an overthrust, and one accessible to tourists, is the peak known as Chief Mountain in the northeastern part of Glacier National Park. This remarkable mountain, which is quite appropriately named, stands out in front of its fellows and faces the plains much as an Indian chief might have done in the early days. Chief Mountain is composed of very ancient, hard and massive rocks, mounted on a pedestal of weaker beds, which from the fossils they contain are known to be hundreds of millions of years younger than the overlying beds and are similar in age and character to those which underlie the neighboring plains.

I hope that any of my hearers who may chance to go to Glacier National Park will visit Chief Mountain, note the presence of the overthrust near its base, and try to read for himself the chapter of the story of the Northern Rockies which is there so clearly recorded.

THE STUFF THAT THINGS ARE MADE OF

By Dr. CHARLES E. MUNROE

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THERE is no desire more universal among mankind than that of wishing to know what the things they encounter are made of. This desire is manifested in infancy; it persists throughout life. Every one has seen a baby reaching out to everything about it and testing everything it encounters by feeling, viewing, smelling and tasting, thus acquiring a knowledge of its form and properties. It is amazing how rapidly an infant learns through these explorations. If only each of us could have maintained through life the interest and power we possessed in infancy, and could remember and recall all we learned at this rate throughout our life, what a learned person each would be.

Watch the progress of those about you from infancy to the grave and you will witness in miniature a moving picture of mankind and its development from its infancy to its present condition. In the early days mankind tried, as the infant does, to distinguish things by their external appearances, characteristics and behaviors, but what a herculean task it was, for, consider vegetation, the multitude of varieties of grasses, of annual and perennial plants, of shrubs and trees; the multitude of varieties of fish in the waters and of insects everywhere; the innumerable micro-organisms; the great number of different animals and reptiles; the large number of different minerals; and the myriad of heavenly bodies. And consider further that no two things in nature are identical. There are no two leaves on the same tree that are precisely alike.

Yet from time to time men have been born with one or more senses especially well developed; a superior eyesight, a special delicacy of touch, a marked acuteness for sounds, or a sharpened sense of taste or smell which enabled him to note differences in the taste or odors of things that ordinary beings fail

to detect. Persons so blessed no doubt reported to others the results of their observations, whereby a body of knowledge was accumulated upon which the philosophic could speculate.

It is amazing how far man went under these conditions. He early practiced agriculture in its many ramifications, though agriculture is perhaps the most complicated and intricate of all arts and industries and one to which a wide variety of sciences contribute. He early noted and employed fermentation, for the Bible tells of Noah's indulgence in wine. Metals, such as gold, silver, iron, tin and copper, were early recognized and used. We were taught that Tubal Cain wrought iron. Colors, such as indigo, were extracted from plants, or, like Tyrian purple, from shellfish, and used in dyeing. Soap-making, another chemical industry, was practiced by the ancients. Naturally then as now there were inquiring minds that sought to know what things were made of and after much speculation, before the time of Christ, and for many centuries after, it was held that there were four elements—earth, air, fire and water—from which all things were made.

When, however, in the fifteenth century, A. D., men began to notice that chemical changes in matter were accompanied by changes in weight and, especially when in the eighteenth century Lavoisier taught the importance of making precise weighings and measurements in the study of matter, man began to perceive that there exist two great and easily distinguishable classes of matter, known, respectively, as simple or elementary matter and as compound matter. The different substances classified as elementary matter are also spoken of as elements, or more precisely as chemical elements. All the countless number of compound substances in nature are built up from the chemical elements.

While the number of compound substances possible is infinitely great, the number of elements is believed to be but ninety-two. The number recognized from the study of matter by many chemists through the use of the most delicate instruments and the most precise methods is now about eighty-eight, so there are some four yet to be found.

Elements have been found through searching everywhere on the earth, under the earth, in the oceans, in the air and on the far-distant heavenly bodies. The ancients discovered the obvious ones. Those like yellow, glistening gold or white, brilliant silver were among the earliest to be discovered. In fact, all those known to the ancients, though not identified as elements, were of the kind that occur *native*. They enter into combination with other elements, yet they are such they can exist free and uncombined in nature in the presence of all the other elements and compounds about them. The majority of elements can not do so, for they are very active and so eager to enter into combination they do not occur free, except as the combinations are resolved and the bonds severed by the chemist in his treatment of their compounds.

However, not all the elements that have from the beginning existed free in nature were recognized by the ancients. Though man from the beginning has lived in constant contact with them, although his continued existence was dependent on his continued use of some of them and although he, in sailing his vessels, in using his windmills, in seeking shelter from the hurricane and the cyclone, admitted their existence, yet because this medium, the atmosphere which surrounds our earth and contains these elements, is invisible, man for countless centuries failed to recognize it for what it is. Like a child of to-day he early recognized solids and liquids, but matter in the gaseous form remained a mystery until some one thought of trapping a portion of it in a vessel and studying its behavior under controlled conditions and with chemical reagents when promptly

an immense amount of new knowledge of nature was acquired.

In 1774, tens of centuries after man had recognized gold, Priestley, by means such as have been described, discovered the element oxygen freely existing in the air. It also is found existing combined in a very great number of different compound substances. In fact, if we take the data from the analyses of the different mineral substances occurring on our earth to a depth of one half mile, in the waters on the earth and the atmosphere surrounding it, oxygen proves to be by far the most abundant of all the chemical elements, and from many standpoints we may fairly say it is the most important of all, though each one has its specific duty to perform and all are essential to the completeness of the universe and the performance of its functions.

On September 5, 1926, on the occasion of the Golden Jubilee of the American Chemical Society, chemists from all over the United States, and many from foreign countries, made a pilgrimage to the grave of Priestley, at Northumberland, Pennsylvania, to do honor to the memory of the discoverer of oxygen.

As the nineteenth century unrolled, the minds of many seemed to have quickened and powerful instruments and devices for research into matter were invented. Of these the spectroscope, through which light could be separated and analyzed, was of the first importance.

Man had long recognized that there were many elements which imparted colors to flames in which they, or compounds containing them, were heated and he had, for some centuries, been using them in fireworks for amusement, though, in recent times, they have been applied to the protection of life and property on railroads and on the waters.

Thus sodium imparts a strong yellow color to a flame; barium, a green color; strontium, a crimson color; and so on. Now, behold! when these flames were viewed through the spectroscope, because of the form of the instrument, the colors appeared within it as colored lines, which always appeared in precisely the same place in the field of view. By examining the spectra of the various elements, it was found that each element produced a characteristic spectrum that was all its own and different from that of any other element.

With the development of spectrum analysis chemists found they had been put into possession of a method of analysis which, in its capacity to detect extremely small quantities of substances, vastly surpassed any method previously known to man. For instance, Swan found he could detect the presence in a flame of the 2,500,000th part of a grain of sodium.

Naturally, with such means at command, chemists began actively to reexamine the matter about them and soon additional elements, such as caesium, rubidium, thallium and indium, which occur in but quite small quantities, were discovered. Not content with a knowledge of the things on this earth spectroscopes were pointed to the sun and other heavenly bodies, and these were found to also be made of such elements as this earth is. Helium, which we now obtain from natural gas, and with which we fill our military dirigibles, was discovered by Lockyer, in the atmosphere of the sun while viewing a solar eclipse through the spectroscope.

Later in the nineteenth century, because Becquerel had observed that certain minerals photographed themselves upon a photographic plate even when both the mineral and the plate were in the dark, Madame Curie was led to examine such minerals with an electroscope, which is an even more searching instrument than the spectroscope, and by proceeding quantitatively, weighing and measuring, she discovered radium and other elements having radioactive properties. When the therapeutic value of radium, in the treatment of cancer

and other diseases, became known and a supply of it, for such uses, was sought, it developed that this element occurs, at least on the surface of the earth and to easily accessible depths, in extremely small quantities, and this furnishes one explanation as to why, through all the ages, this constantly glowing element had remained unknown to man. It is by means such as these the number of known elements has been brought to eighty-eight, the last announced discovery being that of Illinium, due to the cooperative researches of chemists at the University of Illinois and the U. S. Bureau of Standards continued over a considerable period of years.

The discovery that all chemical changes, either in building up a compound from its elements or in separating a compound into its elements, were accompanied with a change in weight, was one of the first importance, especially since it was later found that for any given element this was always perfectly definite in amount, for this led to the belief that this weight attached to a unit portion of each element. Through this, and other evidence, chemists, in the last century, adopted the atomic theory, which taught that all matter is made up of atoms of elements which are built up into molecules, in which the properties of bodies inhere and that these molecules are assembled to form the masses we commonly encounter and recognize. It was further believed that the atom was the smallest portion into which elementary matter could be subdivided and that by no means could the atom be further subdivided.

By comparing the weights of the known elements, and of others as discovered, with that of one of them, taken as a standard, the atomic weights were determined and these weights were used throughout chemical calculations for the control of extensive industrial operations, for the settlement of important financial transactions, in fixing the guilt of one charged with murder and in a great variety of other ways with entire acceptance. In fact, by classifying the elements according to the ascending order of these atomic weights, it was found possible to fix the places of those yet undiscovered and, more wonderful still, to predict the properties such elements, yet to be discovered, would possess, and elements subsequently discovered did possess the properties thus predicted for them.

The belief that an atom was an independent, indivisible entity, composed of the same kind of matter throughout, was generally accepted at the opening of this century. But Madame Curie, through her discovery of radioactive elements, had set investigators to observing how matter behaved when exposed to rays from these and other sources, and soon Rutherford announced to the world his having, by such means, not only knocked portions off of atoms but obtained other kinds of atoms, thus achieving for the first time the long-expected transmutation of elements.

Since the discovery of X-rays it has been known that they can penetrate deeply into matter and disclose its interior. By combining the X-ray with the spectroscope the interior of atoms has been explored, and from the information gathered it is now held that atoms consist of systems, analogous to our solar system, each with a central nucleus (its sun) containing protons, with other particles, called electrons, revolving like planets about the nucleus, and that all is electricity, the protons being positive and the electrons negative, and that one atom differs from another by the number of protons and electrons in its system.

A consequence of this view is that all elements, the molecules they form and the masses built up from their molecules are evolved from a single source. Hence, everything in the universe, including man, has been evolved from the same source, and the difference between the different things that exist is one, not so much of kind, as of number and arrangement.

THE FOOD SUPPLY OF CHINA

By Dr. SHIH TSIN TUNG

THE frequency of famines as well as the prevailing standard of living in China would suggest that there is a serious food problem in that country. But this problem has never received more than local and temporary attention from the people who are really concerned with it. No accurate inventory has ever been taken of the amount of food produced each year or the land area available for food production. It is therefore impossible to launch any intelligent program to solve this fundamental problem of humanity.

However, it should not be too hastily inferred from the above statements that "China is an awfully crowded country." Whether China is overpopulated or not depends upon how the situation is interpreted. To begin with, we may compare the density of the population of several countries, including China, as follows:

Countries	Number of inhabitants per square mile
France	185
Germany	239
India	226
Italy	311
Japan	382
Russia, Europe	54
United Kingdom	389
United States	36
China	104

The population of China, although much denser than that of the United States and Russia, is not so dense as that of Japan, India and some European countries. China, therefore, is not overcrowded at all when her whole territory is considered. However, the actual condition is different. The great majority of the people live in the interior parts of China, which constitute only a little more than one third of the entire area. So the actual density is much higher, being 268 persons per square mile in the 18 provinces where most people live. Even this figure does not show the whole picture of the actual condition, because the average must have been pulled down considerably by the much lower figures of the northwestern and southwestern provinces which, being exceedingly mountainous, are but sparsely inhabited. The population of a few provinces is extremely dense, being as high as 875 per square mile in one case and 600 in another. When it is remembered that most of the people obtain their living from agriculture, and that each province being as large as the average European country and being inadequately supplied with transportation facilities, food is not easily obtainable from outside, it will be realized that the pressure of crowdiness must be severely felt in some localities. A study of the changes of the population in the past discloses the fact that the burden of overpopulation has been on China since a long, long time ago. The four-hundred-million mark was passed as far back as 1842 so far as available statistics show; since then the number has probably never markedly increased. The following table compiled from various sources will illustrate the extremely fluctuating nature of the population of China.

If the above data are reliable, reductions of millions and even tens of millions of people occurring within short periods appeared to have been a common thing. Certainly there are more causes than one

THE POPULATION OF CHINA AT VARIOUS TIMES

Year	Number, 1,000
755 A.D.	23,000
1014	22,000
1097	33,000
1195	48,000
1393	60,000
1381	59,850
1412	65,377
1580	60,692
1662	21,068
1668	25,386
1710	23,312
1711	28,241
1736	125,046
1743	157,344
1753	103,051
1760	143,125
1769	203,916
1761	205,293
1762	198,215
1790	155,250
1792	307,497
1792	333,000
1812	362,467
1842	413,021
1868	404,947
1881	380,000
1882	381,309
1885	377,636
1897	410,000
1909[1]	439,214
1910[2]	342,639

for such extreme cases of depopulation, but the lack of the means of subsistence was undoubtedly one of the most important factors.

In dealing with a subject like the present one, the use of statistical figures is almost unavoidable. As the Chinese government has never been able to engage itself in the peaceful undertaking of collecting complete and reliable statistics of its agriculture, it would be vain effort for the author to pretend the absolute accuracy of whatever figures he might use in connection with this article. But since we can not wait until the government can give us more accurate data and since nobody can do better at present than deal with rough estimates, the writer can be excused for presenting this paper. Of course he will exercise the greatest care and discretion in adopting the figures. In case of doubtfulness he will frankly say so.

In China, as in most other countries, by far the most important food article consists of the cereals. In the following table will be given the production of rice for the five years 1914 to 1918, during which period comparatively more complete reports were secured from the provinces by the central government.

Year	Production, 1,000 "tan"[3]
1914	2,133,483
1915	2,091,956
1916	538,853[4]
1917	526,641[4]
1918	302,297[4]

The first two figures are supposed to be complete, but the last three, while generally cited as representing the total production of rice in China by those who are interested in Chinese agriculture, including the United States Bureau of Agricultural Economics,[5] are short of the amount of six or seven provinces which did not report to the Peking government. Assuming the average rice production of China in a normal year to be equal to the average of the amounts of 1914 and 1915, or 2,124,719,000 tan, we can form an idea of the approximate number of people who may be fed on rice. We will assume that an average person requires about three tan of cleaned rice to carry him through one year, and that two tan of rough rice or paddy are needed for making each "tan" of cleaned rice, and that the rice as reported by the government means rough rice throughout. We will assume, further, that it takes

[1] Customs Office.

[2] Ministry of Interior.

[3] 1 tan = 3.94 bushels.

[4] Incomplete total.

[5] "Foreign Crops and Markets," U. S. D. A. Vol. 6, No. 22.

roughly 10,000,000 "tan" of rough rice as the necessary seeds to start the next crop of 492,680,000 "mou,"[6] which is the average of the acreages of 1914 and 1915. Then rice alone will be sufficient to take care of about 352 millions of people.

The area and production of wheat are given by the Ministry of Agriculture and Commerce as follows:

Year	Area, 1,000 "mou"	Production, 1,000 "tan"
1914	277,298	265,853
1915	266,299	247,106
1916	404,920[7]	360,112[7]
1917[7]	366,795	216,250
1918[7]	571,799	356,748

The totals for the last three years do not contain the amount of all the provinces. But oddly enough, both the area and production are considerably larger than that of the preceding years. The production may vary widely from year to year, but it can hardly be believed that the area under wheat in the provinces which reported increased so fast as more than to cover the loss of the area caused by the withdrawal of several provinces which produce considerable quantities of this crop. It may be supposed, however, that in the first few censuses the government did not discover all the wheat area of all the provinces, and that in later years the officials were better able to require the provinces reporting to report more completely. But for our purpose it seems wise to take the average production of 1914 and 1915, which is 256,479,000 tan. After the necessary amount is deducted from the total for seeds there remains about 236,479,000 tan of wheat for the annual consumption as food. On the basis of three tan of wheat to each person a year, which is a little higher than the average per capita consumption of the Occidental people—an assumption justified by the fact that the people in the West eat considerably larger amounts of other food besides wheat, the above quantity of wheat will be enough for approximately 78,826,000 persons as a principal food article.

[6] 1 "Mou" = 0.15 acre.

[7] Incomplete total.

Other important cereals are millet, about 335 million tan a year, and kaoliang, over 100 million tan per annum. Both of these grains are the principal food items of the people in Northern China. Besides these cereals China also produces large quantities of other crops which are not used primarily for human consumption as a staple food, such as corn, oats, barley, beans, peanuts, potatoes, etc. Some incomplete statistics are given in the following table:

Crops	Units of measure	1917	Production (000 omitted) 1918
Corn	bushel	97,230	171,450
Barley, oats	"	231,000	223,950
Beans	"	441,426	527,787
Peanuts	"	81,447	99,822
Potatoes	ton	2,238	4,384

It appears that China has, besides plenty of cereals for human food, enough grain for feeds to produce enormous quantities of meat. Practically all her people can live on wheat and rice alone if both the statistics and the assumption for the per capita requirement of food are accepted.

China is known as a country largely of vegetarians. There is no large-scale animal husbandry in China as in the new countries. Neither are there many farms solely or even primarily devoted to the rearing of animals. Cattle, the most important farm animal in the west, is kept in China primarily to furnish power for the farm rather than for the purpose of producing meat or milk. Many or most of the Chinese people do not eat cattle meat, largely because of superstition perhaps based on a real mercy to the poor, hard-working beast. Sometimes

the government officials even forbid, by heavy fines and bodily punishments, the slaughtering of cattle. Cow milk is very rare throughout the country. So there is no meat or dairy type of cattle in China. On the other hand, swine are raised almost everywhere, on the farms and even in the villages and towns. Poultry are universally kept by farmers and even by urban people. In South China where rice fields are common and water is abundant it is the rule for farmers to keep ducks. The sheep is a common animal in the north and goats in the south. In the mountainous regions herds of hundreds of sheep or goats are not infrequently met. With this general impression in mind we may go on to the government statistics of farm animals.

NUMBER OF FARM ANIMALS, EGGS AND NUMBER OF ANIMALS SLAUGHTERED IN CHINA

	Number in thousands	
A. Farm Animals:	1914	1915
Horses	4,934	4,744
Cattle	21,997	22,886
Asses	4,394	5,140
Sheep and goats	22,186	23,905
Swine	76,819	60,246
	1917[8]	1918[8]
Poultry	278,706	149,649
Ducks	65,137	52,249
Geese	10,411	5,795
B. Eggs:		
Hen	5,144,359	4,489,703
Duck	1,842,802	1,035,194
Goose	246,161	133,268
C. Animals slaughtered:	1917[8]	1918[8]
Cattle	692	441
Sheep and goats	3,644	3,269
Swine	14,661	12,766

The number of farms is given by the Ministry of Agriculture and Commerce as 59,402,315 for 1914, and 46,776,256 for 1915. The ratio of farm animals to the number of farms seems to agree with our general impression. But it can hardly be believed that the figures for poultry and eggs are obtained by taking a real census of them, as such an undertaking would be impossible under the present condition in China. The number of animals slaughtered is probably more nearly accurate because the butchery of animals is reported and taxed.

We may now attempt to find out the per capita consumption of meat in China. Unfortunately the statistics of meat produced are not complete. The report for 1917 was incomplete by four provinces, the amount of meat for the rest of the country being about 1,549 million catties or about 2,014 million lbs.; that for 1918 did not include six provinces and the amount of meat for the rest of the country was 1,096 million catties or about 1,424 million lbs. The population for the provinces that reported in 1917 and for those reporting in 1918 was, respectively, 344 and 279 millions (according to 1919 post-office estimates). Therefore the per capita consumption of beef, mutton and pork together was from five to six pounds, which is exceedingly low as compared with the Western standards. It must be remembered, however, that the total consumption of meat must be considerably more than the above figures would show because, in the first place, both the weight and number of animals slaughtered were probably underreported on account of the meat taxes, and in the second place, the meat from such sources as poultry, fish and game is not included in the total, and lastly, the provinces omitted in the report probably consume more meat per capita than the rest of the country taken together.

From the above discussion and the personal observation of the writer, it seems safe to say that China produces in normal years just about enough food to feed her people fairly well and that she has as much meat as is absolutely necessary for a normal living, although not

[8] Incomplete total.

plenty of it. In a bad year she is bound to have a really hard time. As the economic status of the people is quite unequal it is needless to say that even in years of abundance some of the poor are only barely fed, while the wealthy lived lavishly even in the worst seasons. And as the country is so large, and the means of transportation so primitive it is very reasonable to expect that local famines occur practically every year and that there are always people starving or struggling for the barest living. In more recent years with the gradual industrialization of China and the rising standard of living in some sections and among some people, the demand for rice and wheat has become greater and greater every year, while on the other hand the production of them has probably been decreasing. Consequently, foreign cereals, particularly rice, are being poured in more and more every year. The average annual value of foodstuffs imported to China in the five years 1913–1918 was more than one hundred million taels of silver. The imports of rice, wheat and flour for 1921 and 1922 are as follows:

	1921		1922	
	Quantity 1,000 piculs[9]	Value 1,000 taels	Quantity	Value
Rice and paddy	10,629	41,221	19,156	79,875
Wheat	81	302	873	3,058
Flour	753	3,504	3,601	16,740

The amounts are indeed insignificant as compared with the food imports of the United Kingdom. But it must be borne in mind that China is supposed to be an agricultural nation and to supply food to the world. It is certainly surprising to find that she is importing both manufactured products and foodstuffs, and that her food imports constitute about 20 per cent. of the total imports of the country.

[9] 1 picul is about 133 lbs. 1 tael is about 581 grains.

Sad as the present situation may appear, there is no need for a pessimistic view of the future if the human factor is to conquer and to make use of its environment. There is a Chinese proverb which describes the condition in China exceedingly well and which may be expressed in the following English words: "Crying for hunger with jewels in hands." China is hungry, but she is not poor, because she has "jewels" in her hands. As soon as her "jewels" are properly utilized she will have no worry for food. Anybody who has any knowledge of geography should know the unlimited natural resources of China. She has the most fertile soils and the most favorable climates that the Creator can give to the world. A glance at the map of China will show that only about one third of the land is settled and cultivated, the other two thirds being yet unexplored. Of course the richest parts of China exist very largely in the well-settled one third of the area, but Manchuria, "the land of opportunities," as the Japanese call it, is as rich as any region of the country. Even in Mongolia, Tibet and Sinkiang extensive fertile tracts of land are reported by individual explorers as well as by government officials. Although nobody knows the exact or even approximate reclaimable area in such vast and untouched territories, the government has secured some figures upon which we may make some estimates. A recent report of the Ministry of Agriculture and Commerce gives the uncultivated cultivable land area as follows: in the interior 18 provinces, 125,065,000 mou; in the eastern three provinces (Manchuria), 788,162,000 mou; in Sinkiang (Chinese Turkestan), 7,594,000 mou; in the three special districts—Jehol, Sueiyuang and Tsahar,

4,425,000 mou; or a total, not including Mongolia and Tibet, of 1,125,246,000 mou. By no means does this figure include all the reclaimable areas in those regions; at best it contains only those that have been discovered and recorded by the government. The best illustration for this inference is given by the province of Sinkiang, which has a total area of over 550,000 square miles or about 2,310 million mou, but which has a reported reclaimable area of only 4 million mou.

The reclaimable land in Mongolia is not reported by the Ministry of Agriculture and Commerce; not even the total area is accurately known. However, just about a year ago the ministry sent out a few men to Mongolia to investigate the conditions of reclamation over that region, and the report of the investigation appeared in a recent issue of the journal of the ministry. We found that these men, after about a month's expedition, probably on horseback in that vast territory, made an estimate—a wild and pure guess—of the reclaimable land area at the large round number of "about one million mou." These people also calculated that Mongolia can support 160,000,000 persons with the average standard of living prevailing in China. Their estimate not only is based on an unreliable assumption of the proportion of cultivable land but also involves an erroneous element in the calculation of the total area. A similar guess was made by the Chinese Bureau of Economic Information which stated in the *Chinese Economic Monthly* (October, 1923, p. 10) that "presuming that half of this area (outer Mongolia) is suitable for agriculture, we have 500,000 square miles or 32,000,000 (really 320,000,000) acres or 192,000,000 (really 1,920,000,000, or still more accurately 2,107,500,000) mou of arable land . . ." Such guesses may hit the actual fact, but we can never trust them because they have absolutely no scientific background.

The writer would put himself in the same situation that he has been criticizing if he were to make guesses, whether more conservative or less so. It is not only futile but misleading for anybody to attempt an estimate of the cultivable area in Mongolia or Tibet, even though he use million or billion as the unit, because nobody can claim that he has any genuine idea of the proportion of land that can be turned to agricultural uses. It means a lack of the sense of responsibility to make guesses purely from imagination. The writer, therefore, instead of making any estimate himself, will merely try to present the situation to the reader, using comparatively more reliable data so far as obtainable and making a few necessary suggestions. He will approach the problem from a different end—the amount of cultivated land—concerning which figures are relatively more trustworthy.

The more complete statistics of cultivated land (field and garden) were those secured in the years 1914 and 1915. For 1914 the total given, excluding Outer Mongolia, Tibet, Kweichow province and the special district of Sueiyuang, was 1,578 million mou; for 1915 the total excluded Outer Mongolia, Tibet, Yunnan province, and Sueiyuang, and was 1,442 million mou. The total cultivated area in Yunnan was given in one year as 11,497,000 mou; that of Kweichow, 1,471,000 mou; that of Sueiyuang, 5,208,000 mou. The area under cultivation in Mongolia was given as 300,000 mou by the Chinese Bureau of Economic Information.[10] As to how much land is cultivated in Tibet nobody dares to say. However, it is believed that the amount must be insignificantly small. It seems

[10] *Chinese Economic Monthly*, October, 1923, p. 10.

safe to say, in view of these facts, that the land area cultivated in all China must not be very far from 1,600 million mou.

Now the total area of all China is estimated at about 4,277,000 square miles, which is roughly equal to 18 billion mou. It means, then, that only about 9 per cent. of the total area of all China is cultivated land. If we disregard the territories of Mongolia, Tibet and Sinkiang and consider only the 18 provinces and Manchuria we would have a much larger proportion of cultivated area, or about 19 per cent. of the total surface. In order to know better the significance of these proportions the writer will compare them with similar figures of a number of other countries in the following:

Country	Year	Percentage of cultivated land of total area
China, all	1914–15	9
" 18 provinces and Manchuria only	"	19
United States	1910	15
Canada	1901	0.8
Argentina	1909–10	6
Belgium	1895	49
Denmark	1907	66
Italy	1911	48
Britain	1911	26
British India	1910–11	43

These figures do not seem to show that China is such an old country. However, it must be pointed out that the cultivated area includes fallows and artificial grasslands and that China has probably a smaller proportion of such lands than the western countries. But this difference will not affect the results very materially. Is China, then, a naturally poor land that can not even ultimately be extensively cultivated? Our impression is that it is far from being such. Our observation leads us to believe that it is probably not far more barren than either America or Europe. We are forced to believe that China is still a new country agriculturally which offers immense opportunities for agricultural expansion. This is about as far as the writer can safely go. He will let the reader form his own opinion with regard to the exact or probable limit to which agriculture may be extended in China. To tell him how many acres or mou can be put under rice, how many under wheat or millet or beans or how many can be used as vegetable gardens or dooryards would merely lead him to pure fancy.

Yet the writer does not feel that he is running a very dangerous risk in saying that the food supply of China can easily be doubled by opening up the virgin soils and by introducing scientific knowledge and practice to Chinese agriculture. Rice may be grown in some of the new regions, since its growing has already made remarkable success in Manchuria. Wheat, millet, kaoliang and other kinds of cereals will find the best type of soil and the most favorable climate in most parts of those territories. There also exist some of the world's best pastures and ranches. With the introduction of productive farm animals into those sections we may look forward to the day when packing plants such as are now found in Chicago will be established somewhere north of Peking, and when Chinese butter and cheese will be also produced in such plants.

But, although any addition of the amount of food equal to that required for four hundred million people to the world's stock is a very material gain, we must not suppose that China will have very large quantities of surplus staple food for the rest of the world. As the standard of living in China is rather low, and as reclamation must necessarily be a slow process and can only be pushed forth by the pressure of population and dear food, the increased output of food will be used largely for rais-

ing the standard of life of her own people and for feeding her own growing population. Her agricultural exports, while they may increase, will be largely confined to certain special products such as beans, vegetable oils, etc., unless the government can adopt very effective measures to promote agriculture and to reclaim the new lands. However, even if China will not export any foodstuffs at all, she will have fulfilled her duty, provided she can feed her own sons well, since she will then be supporting one fourth of the people of the world with only one thirteenth of the land surface.

China's food imports may continue to increase, but China will be able to pay for them, because she is one of the greatest nations on earth to-day whose natural resources other than the surface soil have not been touched. She is rich in minerals and coal and has plenty of water power and human energy. When the rest of the world has been exhausted in everything, it will be the time when China will turn her "jewels" into use. Then if she does not care to produce as much food as she will need and if other parts of the world can produce a surplus, China will buy food, paying with her minerals and manufactured products. So, although China is not very well fed at the present time, she has no more need to grieve for her future food supply than any of the richest countries in the world.

AN ENGINEER'S VIEWPOINT

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SOME twenty or twenty-five years ago we were headed straight for the millennium. A strong optimism seemed to pervade all thought. After centuries and centuries of groping man had come at last to possess sufficient scientific knowledge to utilize nature's forces for his own benefit, and from this starting point civilization would go on and up in one unbroken line of progress. Every new discovery, every new invention was to help the human race along toward a condition where men would live in peace and harmony and where they could enjoy the kindly fruits of the earth with only as much labor as was good for them. What was to happen after this delightful state was reached was not very clear; presumably progress would then cease and we would live happily ever afterwards.

To-day a decidedly pessimistic note has come into man's thinking. To realize this we need only observe the titles of such books as: "The Decline of Western Civilization," "The Revolutions of Civilization," "Mankind at the Crossroads," etc. We have always believed this to be a changing world, but it is only within the last few years that we seem to have applied the facts of history to ourselves and to think that our civilization may be going through a cycle. Our civilization, which we had supposed so stable and believed nothing could overthrow, is now thought by many to exhibit tendencies and changes that will ultimately lead to its collapse. History seems to show that a civilization, like a man, goes through a period of growth, decay and death, and that new civilizations rise out of the ashes of the old. Some of the culture and learning of these old civilizations have been lost; much has been preserved in one way or other.

It is difficult to say what brought about this change in thought. One of the factors appears to be our more complete knowledge of the dates and history of ancient Egyptian and other archeological remains. Furthermore, no one can look at the wonderful sculptures and remains of ancient Greece, and then at the crude work and drawings that appeared during the early middle ages, and then again at the sculptures, cathedrals and pictures that were produced in the fourteenth and following centuries, and not believe that a cycle of some sort—a wave in civilization—had taken place; at least in the field of art. And now, in the last twenty-five years our records have become so complete that Flinders Petrie has been able to trace back some ten thousand years and distinguish eight such rises and falls. These different civilizations he has plotted in a curve, showing the high and low points in a series of waves, one succeeding the other in quite regular order. Some of the wave peaks are higher than others, for art in some of the older civilizations was better than in some of the newer ones. It would naturally be supposed, however, if we could go back far enough into the past, we would find that there had been a gradual increase in the *average* wave height.

History also shows that the way in which civilizations grow and develop is

much the same in each case. Art appears to reach a high point before learning, wealth or prosperity develop. Our own civilization, which started, perhaps, three or four centuries after the birth of Christ, produced its great cathedral architecture about the thirteenth century, while it was one hundred and fifty or two hundred years later before Michelangelo, Raphael and other great artists appeared; and still another hundred and fifty or two hundred years before literature culminated in Shakespeare; and then our scientific knowledge began to develop, while the accumulation of wealth and mechanical invention came last.

This same order of development is shown in all the older civilizations. For example: the Greek and Roman, which was all one civilization, started in Greece, where architecture, art and literature reached their high point. This culture was transmitted, without a break, directly to Rome; after which we find a spread of learning and then a great accumulation of wealth and power.

It is perhaps a little disturbing to think that if history is to repeat itself, it would seem that our present civilization has already produced its great artists and that there will be no more really great ones. Certainly some of the futurists and ultra-moderns of to-day give us reason to stop and ponder over this.

Civilizations appear to disintegrate from an internal wearing out, rather than from any outside cause. A people by the accumulation of wealth and comforts become soft and indolent, and are then either overrun by inferior races or simply degenerate into an inferior race themselves. As to the cause of this decline, there are many theories. The biologist tries to explain it by saying that as economic pressure becomes more and more severe, the families of the better classes become smaller and smaller until finally only a lower grade of intelligence is left.

No entirely satisfactory explanation of the fall of civilizations has yet been advanced and perhaps this of the biologist is the best we have at the moment. The basis of this theory is, of course, heredity; and means that a civilization might endure, if there were a radical change in man's character. Eugenics might do this; or possibly some chemical or physical method of embryonic control may be discovered later that will allow man to produce Nietzsche's overman, Bernard Shaw's superman or any other kind of man desired. Such knowledge, however, might be equivalent to giving mankind a stick of dynamite with which to exterminate himself. This of course is mere speculation and at best is so far in the future that it will be better to consider the question of the fall of civilization from a much more tangible and practical standpoint.

In what has been said the term "civilization" has not been defined; and probably a perfectly satisfactory definition could not be given; but every one will generally understand what is meant. However, so far as our purpose is concerned, definitions are unimportant; and further, it is unimportant whether the detail of development suggested above be accepted or not. The whole point simply is that we must all agree that many civilizations have existed in the past and that culture does not follow a continuously progressive evolution.

Now the question is: "Will our civilization go the way of the others or does it possess any new quality that might make it endure? Is there anything in our civilization which all the others lacked? Yes, there certainly is."

In the past, certain events must have affected mankind profoundly. When man discovered how to kindle a fire, it

must have opened new possibilities in his whole method of living. It allowed him to live in cold countries and to greatly enlarge his diet. Another such event was the domestication of certain animals. These things are prehistoric, but a similar happening has taken place almost under our own eyes and yet most people do not appreciate its full significance.

It is a very strange thing that in all the ages that man has existed on this planet, it is only about one hundred and fifty years ago that he discovered how to machine a flat surface and a cylindrical one. In other words, machine tools had their birth. The ancient world possessed a few crude grinding millstones driven by a rough kind of water wheel, but no machines actuating cutting tools. This may have been due possibly to metallurgical inferiority; but whatever the cause was, it remained for the later part of the eighteenth century to see the development of machine-driven tools.

The possession of two master tools, the lathe and the planer, has made it possible to build upon these as a basis the great superstructure of automatic machinery that we possess to-day. Great difficulty must have been encountered in making the first machines, for every surface, screw thread and spindle had first to be formed by hand. However, by building each new machine with the aid of the last, a reasonable degree of accuracy was finally obtained. In reading the history of the early steam engine, one is impressed with the difficulty Watt had in getting accurate machine work. In contrast to this, think of the great quantity of inexpensive, yet accurately made articles we have to-day—eyeglass lenses, to name only one example.

Before the days of machine tools, such a simple thing as drilling a hole correctly through a metal plate required a high degree of skill. The position of the hole must be carefully laid out, the drill must be so formed as to make a hole that will be truly round and not oval, and the drill must be guided through the plate at the proper angle; all of which required a practiced and highly skilled mechanic. How do we do this to-day? Simply make what is known as a machine jig, consisting of a steel plate the size of the plate to be drilled, in which has been fixed a steel bushing in the exact position for drilling the hole. This jig is given to a boy, who has only to clamp it over the plate to be drilled, put it in a machine and run the drill through the bushing. And now it is as hard for the boy to get it wrong as it was for the skilled man to get it right.

This is technically known as the transference of skill. The skill of the man has been transferred into the machine. In certain machines there is a transference of thought as well as skill. For example, to operate a pianola requires neither skill nor thought. In the shoe manufacturing industry to-day there is not a man who could make a pair of shoes. Pieces of leather are dropped into various machines and afterwards placed together and put into other machines until finally a finished shoe is produced. The shoemaker has become merely a machine tender.

The consequence of all this has been to change society from top to bottom. When textile machinery was first introduced by Jenney, Arkwright and others, it degraded labor, for the skilled workman who had learned this particular trade found himself replaced by unskilled labor and unable to earn his customary wages. Generally speaking, the introduction of machinery causes suffering, until labor adjusts itself to the new conditions and this often means a new generation of workmen before the adjustment is complete. It is true that we still need a few skilled workmen to make

the necessary jigs, dies and special tools, but they are very few, comparatively. However, while labor-saving machinery may at first degrade labor, it eventually produces goods in such abundance and so cheaply that all classes, including the laborer, share in the benefit. Never in history have wealth and comfort been so widespread and enjoyed by so many different classes of men.

A workman used to own his tools, but to-day these have become so elaborate and expensive that great corporations have taken them over and this has changed the old-time relation of employer and employee. The personal contact is gone, men are treated in a different way; organization, systematization, standardization are everywhere. Material advancement has come so fast that we have not had time to adjust ourselves to the new conditions, and this is undoubtedly the real cause of our labor difficulties. Just as the engineer brought about this industrial age, there is now some reason to believe he may bring the solution for its attendant troubles. It is a very significant fact that each year there are more and more technically trained graduates going into managerial positions. In other words, scientific knowledge and background are beginning to be applied to human engineering. In the last analysis the only real solution is education; education of both laborer and employer.

It may be argued that mankind was happier before this industrial age, with its railroads, its great steamships, telegraphs, telephones and the rest and that the tending of machines makes a workman into a mere automaton, deadening his faculties and killing his ambition and inspiration. There are, of course, two sides to this question; but whether it be true or not and whether we like it or not, the handwriting on the wall says that industrialism has come to stay and to increase. The signs read this way. The mechanical revolution not only made mass production possible, but it allowed science to advance by leaps and bounds. The high precision machine-made instruments have opened many closed doors of knowledge. Think of the accurately ground lens, the ruling engine and even surgical instruments.

The modern engineer, then, is the one thing in our civilization which no other civilization ever possessed. We differ from the past, in the wide spread of knowledge, the binding together of civilized peoples by railroads, telephones and telegraphs, the greater wealth in the world, the more uniform distribution of it, the much better condition of the working classes and the other things that came with the industrial revolution.

Is it possible that these new conditions can make our civilization endure? The mere fact that we have more material comforts does not mean that we are better or happier than men of past civilizations. The race does not reach happiness by mechanical or industrial progress. Man does not live by bread alone. He must progress intellectually and spiritually as well. When man ceases to strive he goes backward; and if security and plenty mean mental stagnation, then surely industrialism will only push him faster to the end. Yet there are certain influences acting to-day that must have a tendency to prolong at least the coming of this end.

Civilization can fall in only two ways. Either civilized man must deteriorate and change into uncivilized man or else he must be overrun and his culture stamped out. In the past, generally both of these have acted together; man first deteriorating and then some strong, hardy race, often from the north, coming down and conquering him. Sometimes the conquerors intermarried with the conquered and from this new infu-

sion of blood another civilization has in time started to rise.

The tendency of our age, due to railways, telegraphs and modern means of communication, is to spread civilization into the uncivilized portions of the globe, and to make the culture of the whole world more homogeneous. With culture so widespread a general deterioration of all civilized peoples at the same time is much less likely than in the more circumscribed communities of ancient times. The fact that cultured peoples are so scattered makes it difficult, too, to see how the oriental, for instance, could overrun and stamp out all western civilization. He might overrun part of the world, but western civilization covers a very large area. Then, too, the oriental may become westernized enough to prevent this. At any rate, we may conclude that modern conditions have in them a quality which will, at least, tend to prolong our present civilization and put further off that evil day when a general or partial deterioration may wreck or even destroy our culture.

There is one aspect of this question that should not be overlooked. In order that our civilization may continue we must have metals with which to build machines and coal to furnish power.

Metals have been produced and the arts of forging and tempering known since ancient times. An iron tool found in the pyramid of Kephron probably dates from 3500 B.C. and Homer compares the hissing of the stake thrown by Ulysses to that of the steel which the smith quenches in water. The ancient world was able to extract wrought iron only, and it was not until the fourteenth century A.D. that large furnaces and stronger air blasts made it possible to cast iron; somewhat as bronze had been cast long before. The small amount of iron ore that had been used before the advent of the modern blast furnace had made no impression whatever on the immense reserves contained in the earth; but now that modern metallurgy is demanding such enormous quantities of ore, our mineral resources are being used up at an alarming rate.

Coal, too, as well as iron ore, is necessary for our age. The industrial world of to-day is able to utilize but two sources of energy, *viz.*, water power and coal. Only about one fifth of the potential water power of the United States is at present developed; but even if it were all developed, it would not have carried the industrial load of the country during the year 1922 (for which the figures are available). Furthermore, estimates show that the industrial load of the United States is growing very rapidly. For instance, if the load curves of Pennsylvania, our greatest industrial state, are projected into the future, the indications are that the power demand will have doubled by the year 1950. This means that as the industrial world becomes larger and larger we must depend upon coal almost entirely.

The coal reserves of the world are fairly well known, and from some late estimates it would seem that a few hundred years will see the exhaustion of all our best coal. This means that industrial prosperity would reach its zenith at that time and from then on there would be a gradual decline in industry. As some one has said, it is a fortunate thing for us that the industrial age did not begin in the time of Tutankhamen or today we would be fighting among ourselves for the last few remaining heat units.

As to other fuels, our natural gas and wood are pretty well gone already and our oil is following very fast. Such sources of energy as wind, wave, the sun's radiation, the internal heat of the earth (if it exists), etc., can all be put in the same class. They have all been

tried and all proved unsuccessful. The chief reason is that the power is too diffuse. For example, it would require an enormous platform riding on the waves to generate even a few horsepower. Great numbers of parabolic mirrors have been placed around a boiler to gather the sun's rays, but have been unable to raise steam, much if any, above atmospheric pressure. It is true that some power can be obtained from these sources, but to develop by their means the tremendous amount of power demanded by the industrial world is entirely out of the question. Whether science will later tell us how to utilize the energy that we believe to be in the atom is doubtful to say the least.

The application of scientific principles has been so rapid and we have seen such spectacular changes taking place in industrial life that we have come to believe this development will continue and that sooner or later some one will stumble on some great source of energy other than coal. We are like Micawber, waiting for something to turn up. A much more logical attitude would be one of trying to conserve our resources. Future generations may regard the way this generation wasted natural resources as little short of a crime. Considerations of this kind, however, generally conclude with the question, "What has posterity ever done for us?"

The exhaustion of our natural resources has a very important bearing on the duration of our industrial civilization and may limit it and even bring it to an end.

THE SCIENTIFIC MEN OF THE WORLD

By J. McKEEN CATTELL

THERE has for a long time been planned a study of the scientific men of the world on the lines of the statistical work on American men of science. International directories in the several sciences were taken up, those in psychology and zoology having been partly prepared, the latter in cooperation with Professor T. D. A. Cockerell. In connection with the third edition of the Biographical Directory of American Men of Science it was proposed to select by objective methods the thousand leading scientific men of the world. With such a list it would be possible to determine among other things the value of the contributions of each country to each science, both in quantity of work accomplished and in fundamental advances.

In order to obtain preliminary data I wrote in June, 1914, to the scientific academies of different countries asking for their membership lists. These were mailed from most of the German and other academies after war had begun It was obviously impossible to continue the work at that time; it was indeed necessary to postpone the preparation of the third edition of American Men of Science. We have scarcely yet reached a situation where international cooperation and unprejudiced judgments are feasible; but the methods used enable us to measure validity of judgments and prejudice, so that the study might at the present time be of special interest from that point of view. We could, for example, measure the normal distortion of judgment through nationality, its excessive manifestation during war and its subsequent waning.

In connection with the study begun some years ago I counted up the scientific men of different countries in "Who's Who in Science," edited by H. H. Stephenson and published in England by Churchill. There has been no edition of the book since 1914, and the figures just before the war are no longer valid, but they have sufficient interest to warrant their publication, more especially in view of the recent widely quoted remark by Secretary Hoover to the effect that the United States is behind most European countries in its contributions to pure science and the statement of the National Research Endowment of the National Academy of Sciences to the effect that "the United States, which already occupies a leading position in industrial researches, should rank with the most enlightened nations in the advancement of pure science."

The scientific men whose biographies are included in "Who's Who in Science" and whose numbers are given in the table were probably selected somewhat at random, those of Great Britain and its colonial empire being the most completely represented and the United States coming next. Perhaps 800 from Great Britain and 1,200 from the United States would be a fairer basis for comparison with other countries than the 1,729 given from the former and the 1,845 from the latter. In that case Germany would be in the lead. The numbers from the non-English speaking nations may be regarded as comparable, though they doubtless vary with the sources of information.

If we take the figures as they stand, the United States, Great Britain and Germany were in 1914 far in advance of other nations in the numbers of their scientific men. France had 504, as com-

THE DISTRIBUTION OF SCIENTIFIC MEN ACCORDING TO "WHO'S WHO IN SCIENCE," 1914

	Medicine Surgery	Chemistry	Engineering	Zoology	Mathematics	Geology Mineralogy	Physics	Botany	Physiology Pharmacology	Astronomy Meteorology	Pathology	Anatomy	Agriculture Forestry	Psychology	Geography	Anthropology	Total	Per million ca. 1880	Per million ca. 1920
United States	206	215	201	184	126	135	131	114	86	75	60	54	76	95	18	30	**1845**	*58.7*	*17.4*
Great Britain	252	295	349	118	86	90	104	78	53	64	51	37	59	30	42	21	**1729**	*59.4*	*36.6*
Germany	221	144	128	90	115	93	104	75	59	63	39	53	48	37	44	21	**1334**	*35.0*	*22.3*
France	109	52	23	32	32	27	39	16	33	16	39	24	8	12	16	16	**504**	*13.7*	*12.8*
Austria-Hungary..	67	56	42	27	39	31	40	21	24	22	22	31	7	14	18	6	**467**	*13.5*	*8.8*
Asia	40	39	47	16	9	9	14	21	16	14	6	8	21	3	6	0	**269**	—	—
Italy	37	17	8	13	29	18	18	10	16	14	21	11	1	12	16	5	**246**	*9.8*	*6.3*
Switzerland	38	26	13	16	19	12	9	11	15	5	13	9	6	10	9	4	**215**	*86.0*	*55.1*
Norway	34	15	21	18	8	14	9	11	8	7	3	3	8	6	3	2	**170**	*106.2*	*65.4*
Holland	18	14	3	39	9	8	12	10	13	7	9	6	0	6	4	1	**159**	*48.2*	*23.4*
Canada	16	18	19	9	7	29	13	5	7	6	6	3	7	2	1	5	**158**	*45.0*	*17.4*
Australasia	12	11	30	10	10	19	8	7	4	8	5	4	10	3	1	3	**145**	*120.0*	*19.4*
Russia	19	17	10	12	12	10	9	9	5	8	5	8	0	6	3	3	**186**	*2.0*	*1.3*
Sweden	20	17	6	10	8	9	5	11	6	8	2	9	0	4	7	2	**124**	*32.6*	*21.0*
Denmark	11	11	11	9	7	1	3	9	8	3	4	4	4	2	1	0	**97**	*60.6*	*29.4*
Belgium	20	9	7	8	6	3	3	5	7	2	10	4	0	2	3	1	**90**	*19.1*	*12.0*
Africa	11	4	15	11	6	8	2	8	1	10	2	1	8	0	1	0	**88**	---	
Spain	6	7	1	4	4	4	5	1	2	5	7	6	0	2	1	3	**58**	*3.7*	*2.7*
S. & C. America ..	5	2	3	5	2	8	2	3	1	10	3	0	3	2	1	2	**52**	—	—
Portugal	6	2	1	3	7	4	4	3	3	1	4	4	0	2	2	1	**47**	*13.0*	*7.8*
Bulgaria	0	3	0	3	2	2	1	1	0	1	0	0	0	0	0	1	**14**	*7.0*	*2.8*
Roumania	0	1	0	1	2	0	1	0	1	1	0	1	0	0	0	0	**8**	*2.0*	*.5*
Greece	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**2**	*1.8*	*.4*
Servia	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	**2**	*2.0*	*.4*
Malta	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	**1**	*7.1*	*4.4*
Total	**1158**	**1006**	**941**	**638**	**546**	**537**	**536**	**429**	**369**	**351**	**320**	**280**	**266**	**250**	**201**	**127**	**7955**		
U. S. Per cent.	*18*	*24*	*21*	*.20*	*23*	*25*	*24*	*27*	*23*	*.21*	*22*	*19*	*29*	*38*	*08*	*.24*	*23*		

pared with 1,334 from Germany; the then Austria-Hungary with 467 was nearly equal to France; Italy had 246. There then follow Switzerland with 215, Norway with 170 and Holland with 159. Sweden has 124 and Denmark 97.

According to the figures in the table referring to the several sciences, the United States stands higher in the so-called pure sciences than in medicine and engineering. We indeed stand first in all the natural and exact sciences except chemistry (largely an applied science) and geography. It is naturally gratifying to the present writer that psychology is the science in which we are most decidedly in the lead. We have 95 of the world's leading psychologists as compared with 30 in Great Britain, 37 in Germany and 12 in France. Geography is the science in which we are most deficient, 18 geographers being attributed to the United States, as compared with 44 to Germany and 42 to Great Britain. After psychology we are strongest in zoology, botany, agriculture and geology. This is what I guessed in a preceding discussion[1] of the subject, but I then added astronomy to psychology, zoology, botany and geology as the subjects in which we were probably in the van. The sciences in which we make relatively the poorest showing in the table, apart from the applied sciences and geography, are anatomy and astronomy. The differences in the percentages for the different sciences are, however, not large and would probably fall within the probable errors of sampling if these could be determined.

The figures in the table relate to a period preceding 1914. They do not have great validity even for that time, and the years that have since elapsed

[1] "Scientific Research in the United States," *Science*, February 12, 1926.

have been significant for international changes. The edition of American Men of Science published in 1910 contains about 5,500 biographies of those who are supposed to have made contributions to science, the edition now in course of preparation will contain in the neighborhood of 15,000. The increase may to some extent be due to more complete representation, but in the main it measures the increase in the number of scientific workers. They have probably about doubled since the data were compiled for "Who's Who in Science." The increase has been much less elsewhere; indeed there may have been none in some nations, such as France and Italy. With the possible exception of Germany the United States is now far in advance of every other nation in the number of its scientific men and in the number of its contributions to science.

It does not follow that the number of great men of science and the significant contributions are proportional to the total number of workers and the total amount of publication, although this is perhaps the most probable situation if there is no information to the contrary. It seems that England and ancient Greece have produced more than their share of the greatest men and this was indeed found to be the case in my study of the eminent men in the world's history.[2] It may be that at the present time Holland with 12 physicists attributed to it is making more important contributions to that science than the United States with 131. In psychology, which is the only subject on which I can speak with adequate information, we appear to lead in importance as well as in quantity of work.

In the last two columns of the table are given the numbers of scientific men in proportion to the populations of the different countries. The first column gives the numbers per million in 1860, which was about the average time at which they were born; the second column gives the numbers in relation to the present populations. In France, with a nearly stationary population, the figures in the two columns are of course nearly the same. In the United States and the British Dominions, with rapidly increasing populations, the proportion is much smaller in relation to the existing population than to the birth rate. For a given stock and civilization, if scientific productivity were wholly due to the innate constitution of the individual, the numbers should be proportional to the population at the time of their birth; if wholly due to opportunity it should be proportional to the existing population. An adequate study might contribute toward the solution of this problem.

Taking either the one figure or the other in the table, it is obvious that while in total productivity we may surpass every other nation, this is far from being the case in proportion to our population. This situation is still less creditable to us when wealth and opportunities for higher education are taken into consideration. It should, however, be noted that the lower figures can be attributed in part to the large Negro and immigrant populations and to an unproductive South. Our scientific men appear now to be increasing about four times as rapidly as the population, and the figures in the table have for this and other reasons (including redistribution of populations after the war) only a limited application. When allowance is made for disturbing factors, the number of scientific men of standing in proportion to the present population appears to be nearly the same in the United States, Great Britain and Germany, about half as large in France and a quarter as large in Italy. Norway and Switzerland have

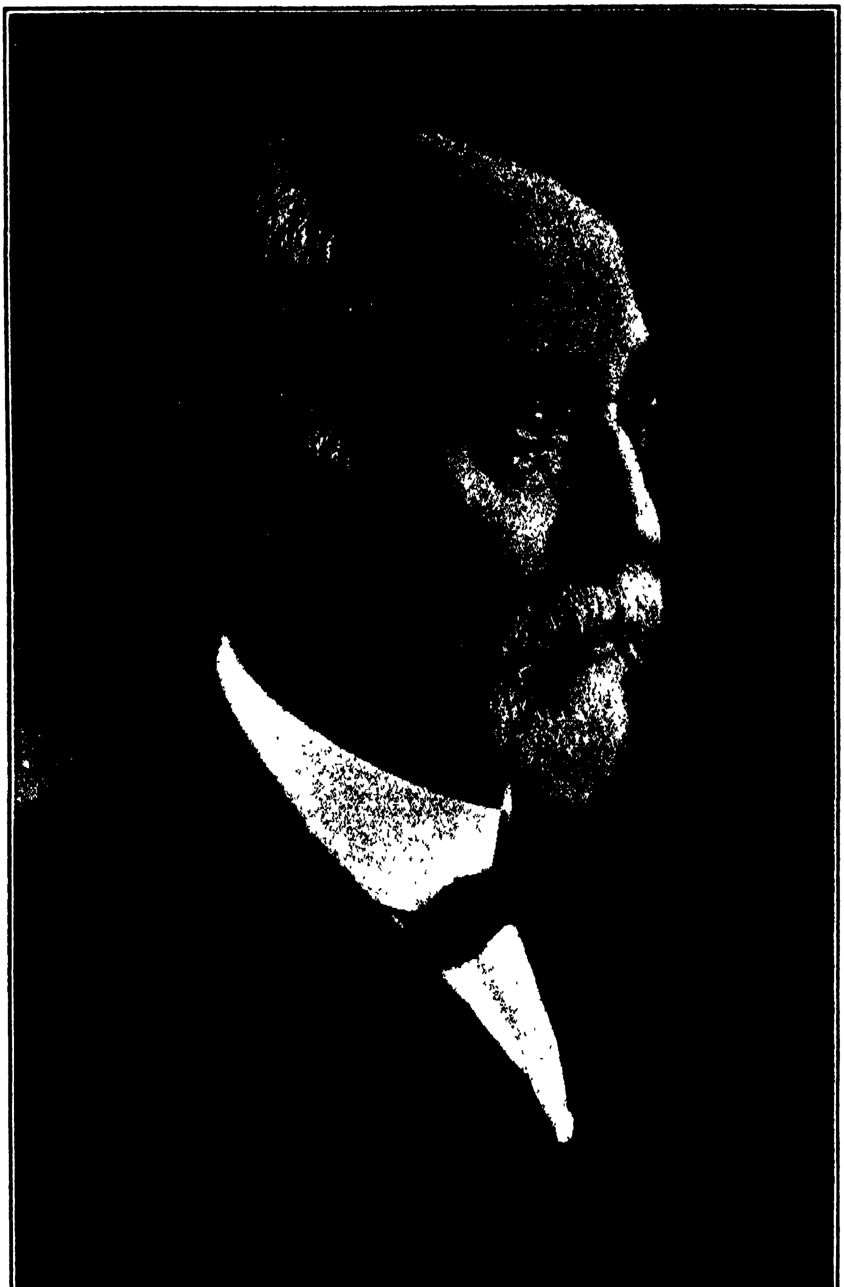
[2] "A Statistical Study of Eminent Men," *The Popular Science Monthly*, February, 1903.

by far the largest proportion, followed among the smaller nations by Denmark. Holland and Sweden. I should have expected Holland to stand first, and it may, for the figures collected from the book have inconsiderable validity.

The greater relative productivity of the smaller cultural nations in science—the same situation probably holding in literature and in art—is a matter of considerable interest. It goes back to the Greek democracies and to the Italian states of the renaissance. In this country we had a local development in Massachusetts and Connecticut, in which, according to my statistics, the birth rate per million population of scientific men more highly selected than those on the international list was 109 and 87, respectively. If these figures are increased to make up for the number of scientific men given in the table, they become, respectively, 201 and 160, a much larger birth rate of scientific men than that of any foreign nation. It is probable that a similar situation now holds in California and in parts of the central west.

We apparently need regional cultivation of special fields with a group and a community interest in the work. The situation is difficult for with the increasing complexity of science and in our existing competitive system there must be support of research through taxation or gifts. But control from Washington, whether by the national government, or by a group of men who administer philanthropic funds, may do more to suppress research than to forward it, the rarer flowers of genius being particularly apt to wither when frost and sunlight are artificially controlled.

We are so ignorant of the causes of scientific productivity that it is possible for Galton to attribute it almost wholly to heredity in superior lines of descent, for Odin to claim that genius is in things, not in men. Yet it is a subject of fundamental importance both from the point of view of constructive science and for the applications of science to human welfare. The field is nearly untilled and for that very reason may prove to be fertile.



—*From Nature*

PROFESSOR H. A. LORENTZ

THE DISTINGUISHED DUTCH MATHEMATICAL PHYSICIST, WHO IS VISITING THIS COUNTRY TO GIVE LECTURES AT THE CALIFORNIA INSTITUTE.

THE PROGRESS OF SCIENCE

By Dr. Edwin E. Slosson
Director of Science Service, Washington, D. C.

TROPICAL WEALTH

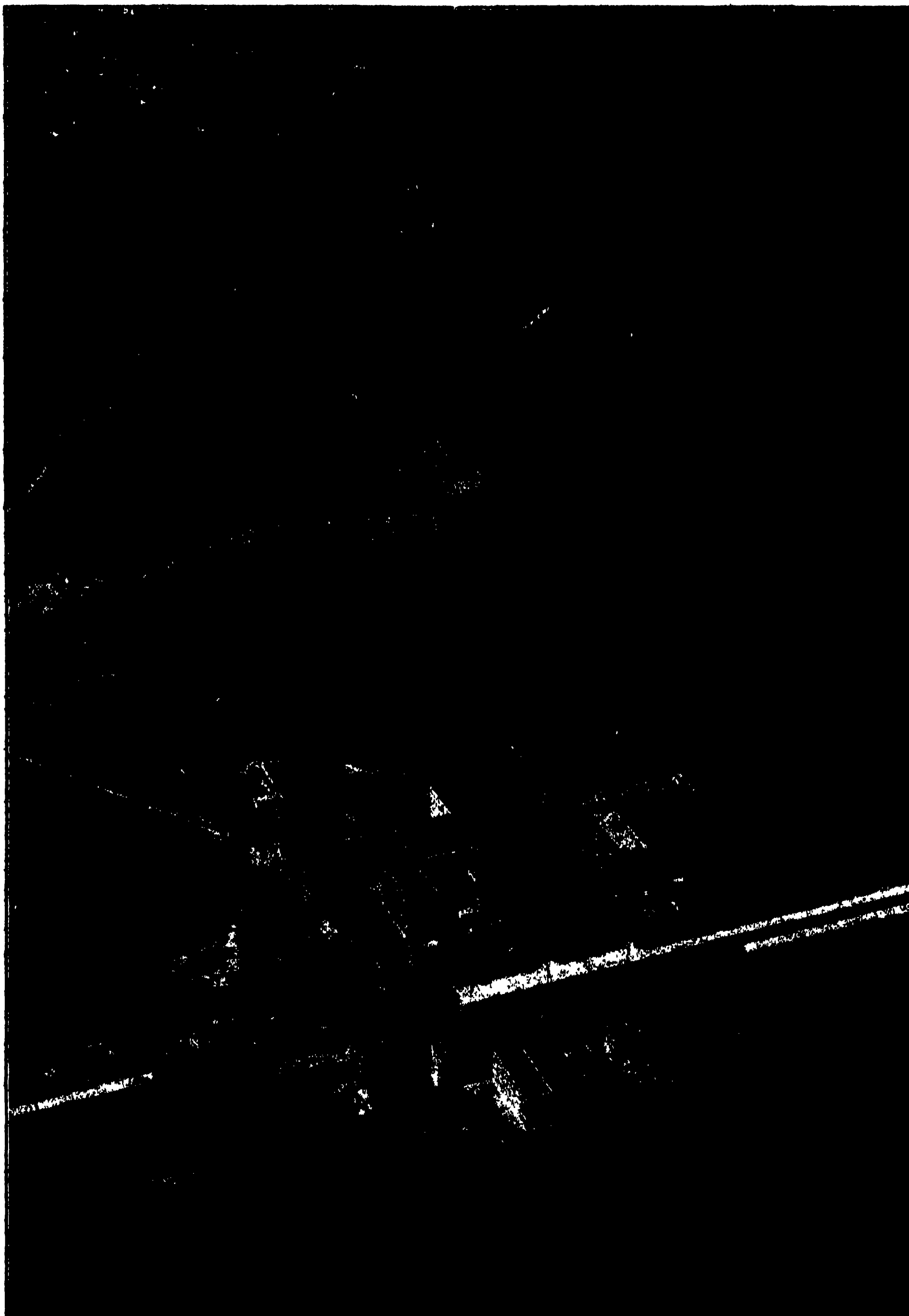
I have just received the reports of the British Association for the Advancement of Science and am much struck by the contrast between the parent association and the American Association for the Advancement of Science. In the British Association much more attention is given to the scientific aspects of the industrial and commercial development of the empire than is customary in the American Association.

At the recent Oxford meeting the presidential address of the Section on Geography was given by the Honorable W. Ormsby-Gore, Member of Parliament and Under-Secretary of State for the Colonies, who spoke on "The Economic Development of Tropical Africa and its Effect on the Native Population." He began by calling attention to the fact that "four million square miles of Africa lie within the British Empire. In fact there is more of the British Empire in Africa than in any other continent. British North America and Australasia are both smaller in area than the African possessions of the Crown. Approximately three quarters of this African area lie within the Tropics."

The advantages which Great Britain gets from her African dependencies is illustrated by a few of the figures that he gives. The domestic exports of Nigeria in 1921 were valued at $41,-250,000, in 1925 they had risen to $85,-000,000, more than double. In 1921 the Gold Coast products were valued at $30,-000,000, in 1925 they were worth $52,-500,000. These examples of expansion in West Africa are eclipsed by the rate of progress in East Africa. The domestic exports of Kenya and Uganda in 1921 were $11,250,000, in 1925 $39,100,000. What used to be German East Africa but is now rechristened Tanganyika Territory produced in 1921 products valued at $5,000,000, in 1925 these were $14,500,000. The two most sensational examples of the expansion have been cocoa in the Gold Coast and cotton in Uganda. The exportation of cocoa from the Gold Coast rose from 7,000 tons in 1905 to 78,000 tons in 1915 and 220,000 tons (nearly half the world's total supply) in 1925.

The peanut, which most Americans regard as merely a rival for popcorn as a mid-meal nibble, is becoming in Africa a source of oil for shortening, for soap making and for Diesel engines. The export of peanuts from Nigeria was nothing in 1910 and 120,000 tons last year. These figures will serve to intimate the rich revenues which Great Britain is gaining from the African territories that she possessed before the war and which she has acquired from Germany through the war.

The United States is handicapped in comparison with her commercial rivals by lack of tropical territory. England, France, Holland and Portugal are far more fortunate in this respect. England has about a hundred times as much territory as the United States in tropical or semi-tropical climes; France has over 34 times; Holland and Portugal have each more than seven times as much as the United States.



THE SCHOOL OF MEDICINE AND DENTISTRY OF THE UNIVERSITY OF ROCHESTER

THIS PHOTOGRAPH FROM THE AIR SHOWS THE BUILDINGS DEDICATED WITH SUITABLE CEREMONIES ON OCTOBER 25TH AND 26TH.

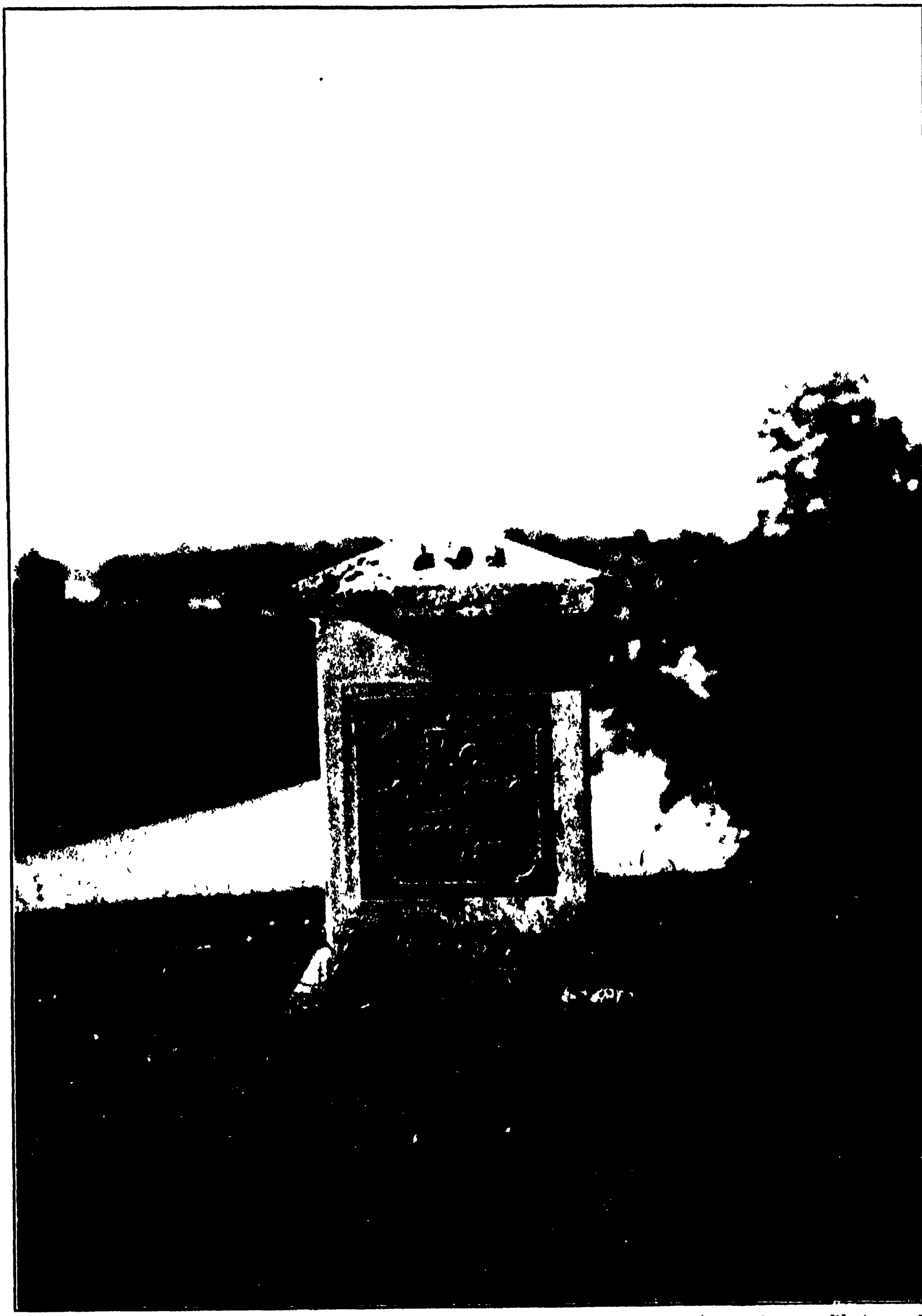
DRIVING A HALF MILLION HORSES

I HOLD in my hand as I am writing the tooth of a horse. Yes, that is literally true, for I am so skilful on the typewriter that I can run it with two fingers of one hand with an occasional punch with the left thumb, and the tooth is not attached to the horse. In fact, the owner of the tooth has been dead for some 25,000 years. For this is a relic of one of the earliest horses made use of by man. It was picked up last summer at Solutre in France where tons of bones of a hundred thousand horses are piled up about a prehistoric camp of two acres area like tin cans about a frontier town. They are alike the débris of the kitchen. Yet before the Solutreans had deserted this site they had perhaps learned how to utilize the energy of the living horse, for an engraving has been found of the outline of a horse with some scratches on his head that look like a halter.

This then marks about the beginning of what we might call the Equine Epoch of human history, which is visibly drawing to an end in our generation. Look down a street of any of our large cities and you will rarely see a solitary horse struggling to hold his place in the throng of his mechanical rivals.

For the patient beasts of burden which primitive man trained to work for him, the horse, the ox, the ass, the elephant and the camel, are neither strong enough nor speedy enough to meet the needs of modern man. Nor are they tractable enough. "The horse is a vain thing for safety," said the Psalmist. That is because the horse has a will of its own. So has the mule. But machinery behaves more rationally than animals because it is the offspring of man's reason, created expressly to do his will. Being made after the manner of man's own mind, it is more completely under his control, provided he knows enough to manage what he has made.

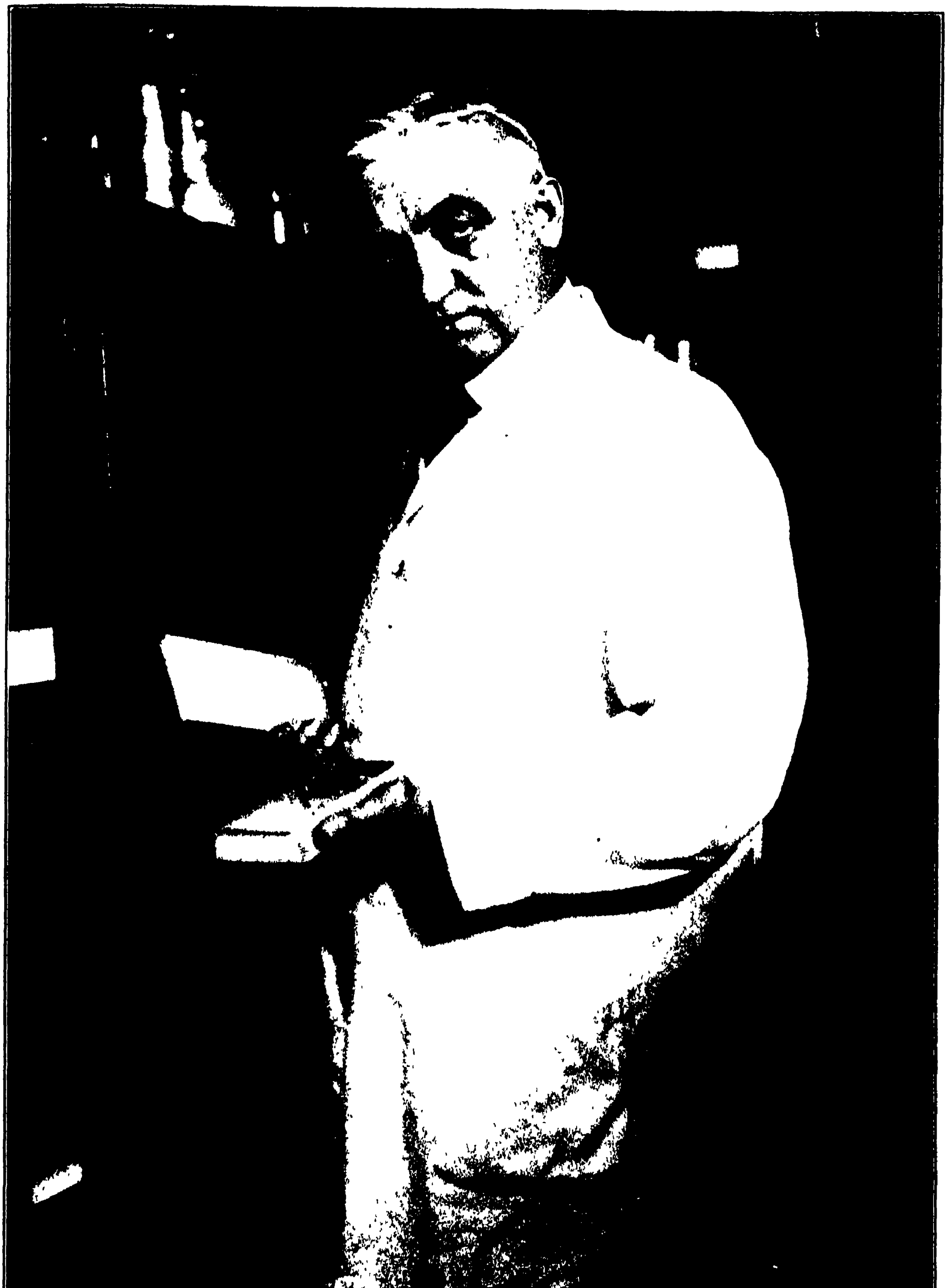
To drive a team of six or eight horses requires a man of peculiar strength and skill. Yet the other day I saw a man driving a team of nearly 500,000 horsepower with the greatest of ease. It was in the switch room of the Niagara power house. In the middle of the clean and empty room was a desk at which sat two men. One was reading a paper so I don't count him. The other sat quietly and for the most part idly, though keeping a watchful eye on the dials, signals and switches that encircled him on the walls. Occasionally he touched a button or pulled a handle, jotted down a figure on a sheet of paper on the desk or took up the telephone. He looked more like a bank president than a "workingman." He must have to do a daily dozen to the tune of a radio in order to get enough exercise. Yet he had under his thumb the highest powered prime-movers in the world, three hydro-electric units capable of carrying a load of about 84,000 horsepower each. Only seven men are required to run the entire plant, but fourteen more are needed to show visitors around. These turbines and dynamos, with their few attendants, distribute light and power to an area of two million people. Such an example of individual control and democratic distribution would be impossible to accomplish with any number of horses—or elephants. It is an epitome of human progress, this passage from the hundred thousand horses that the Solutreans ate to maintain their muscular energy, on up to the five hundred thousand horsepower waterfall that this man employs to replace human energy.



- *Science Service Photograph*

EARTH'S OLDEST GRAVE

THIS MONUMENT WAS ERECTED BY DR. EUGENE DUBOIS TO INDICATE THE SPOT WHERE HE FOUND THE REMAINS OF PITHECANTHROPUS ERECTUS, SO-CALLED "APE-MAN," AT TRINIL, JAVA, 35 YEARS AGO. IT IS AT A LITTLE DISTANCE FROM THE EXACT SITE, TOWARD WHICH THE ARROW POINTS. THE RECENT FIND OF A NEW RELIC OF PITHECANTHROPUS WAS MADE NEAR THIS SAME SPOT.



Science Service Photograph

THE YOUNGEST HUMAN EMBRYO

DR. G. L. STREETER, DIRECTOR OF THE DEPARTMENT OF EMBRYOLOGY OF THE CARNEGIE INSTITUTION OF WASHINGTON, HOLDING BOX OF MICROSCOPE SLIDES ON WHICH ARE PRESERVED SECTIONS OF THE MILLER OVUM, THE EARLIEST-STAGE HUMAN EMBRYO SO FAR DISCOVERED. IT IS KEPT AT THE JOHNS HOPKINS UNIVERSITY.

SCIENCE IN DAILY LIFE

THE American Library Association has asked me to write something about the importance of the physical sciences for one of their forthcoming pamphlets on "Reading with a Purpose." This is what I said:

Ignorance of the laws of nature excuses no one. We have to live in accordance with them if we are to live at all, and the more we know of them the better we can live. The unprecedented expansion of civilization in the last two centuries, the immense increase in wealth and the general diffusion of the comforts and conveniences of life, must be credited chiefly to applied science, and especially to the physical sciences, since the biological, psychological and social sciences have not yet developed to a point where they exert so powerful an influence upon mankind.

It is interesting and important to learn about things far away and long ago, such for instance as the habits of the auks of the Arctic or life in Egypt in the time of the Pharaoh Tut-Ankh-Amen, but after all we can live, and even be happy, in complete ignorance of these things. But we can not carry on our work for a day without making some use of the laws of the physical sciences whether we are conscious of them or not.

Fortunately we are forced to learn a lot about them in our infancy, long before we go to school. It is pounded into our brains by hard knocks. We have to acquire a practical knowledge of the law of gravitation in childhood before we are able to walk, and we learn a good deal about chemistry by the experimental method of putting everything into our mouths and so testing it by taste and smell, which are the two senses that distinguish substances by their chemical constitution.

So every grown person, though he may never have been to school, gains through his daily life and occupation a considerable knowledge of the physical sciences. He gets, for instance, a certain familiarity with the physical principles of machinery and with the chemical properties of metals and foods. But the knowledge so accidentally acquired is fragmentary and often fallacious. The information that he has so picked up is not connected, and he can not apply it to new problems. Such a man knows more than he knows he knows, but he is not able to make full use of it because he has never connected his facts or generalized his ideas. In short, such a casual collection of fragmentary facts is not science, but merely the raw material for science. What such a man needs is to read some simple systematic work on the physical sciences, and he will then find that the practical points he has picked up will fall into their proper places in the general laws, and that these laws will extend his vision and throw new light on all that he sees and does ever after. To study physics and chemistry is like giving sight to a blind man. It opens to him a new world of undreamed-of beauty, meaning and possibilities.

But simply because these physical sciences are so fundamental and essential they are apt to be overlooked and neglected in the acquirement of culture. When tourists visit a Gothic cathedral many of them see nothing but the frescoes and gargoyles, and give no thought to the architectural principles of its structure, yet the esthetic effect of the edifice is due largely to the way the structural principles are revealed in its pillars, buttresses and arches. One who fails to get that misses, not only the meaning, but much of the beauty of the building. So, too, one who, for lack of acquaintance with the physical sciences, does not see the inner meaning of the acts and processes of daily life, not only is hampered in their control, but loses the enjoyment of their significance.

EXHIBIT OF THE SMITHSONIAN INSTITUTION AT THE SESQUICENTENNIAL EXPOSITION

DR. JAMES M. GIDLEY, OF THE U. S. NATIONAL MUSEUM, IS SHOWN WITH ONE OF THE EXHIBITS PREPARED BY HIM FOR PHILADELPHIA. THE SKELETONS ARE TWO PORTHEUS FISHES, ONE TWELVE FEET IN LENGTH WHICH IS SWALLOWING ANOTHER WHICH MEASURES SIX FEET. THE BONES WERE FOUND IN KANSAS, WHERE THE GIANTS FLOURISHED MILLIONS OF YEARS AGO.

THE FLORIDA HURRICANE

Science Service

THREE severe tropical hurricanes in the region around the Caribbean Sea at the same time, one of which was the disastrous storm which swept Florida and the northern Gulf Coast, have made a new kind of weather record, according to Charles L. Mitchell, of the U. S. Weather Bureau.

Fortunately, only one of the three got to the mainland of the United States. One of the others kept to sea as it passed up the Atlantic Coast, and it was this one that prevented Captain René Fonck from taking off on his airplane flight to Paris immediately after he had repaired his leaking gas tank. The third member of the trio passed northwards over Cuba, and then disappeared with the proximity of the Miami hurricane.

But though millions of dollars' worth of damage was done in Florida, the storm was not a surprise to the Weather Bureau officials, for they had been observing its progress since the fourteenth of September. Warnings of a hurricane along the eastern coast of Florida were sent out on the evening of Friday, September 17, preceded by warnings of a severe storm the same morning.

The origin of the storm was off the west coast of Africa, near the Cape Verde Islands, a favorite breeding place of such hurricanes, and the Atlantic storm began in the same general region. The Miami storm began about September 18, the mass of whirling air that constitutes such a hurricane then passing westward across the Atlantic, and, when it hit Florida, traveling with a speed of about 125 miles a day.

Apparently the center of the storm passed right over Miami, for at the center of the whirl of air is a calm spot perhaps forty miles across, called the "eye of the storm." After the first severe blow at Miami, the storm apparently ceased, but as the rescuers were beginning their work it broke again with increased fury, but then the wind, instead of coming from the northeast, as it had at first, came from the southwest. While it was at its height, the wind velocity went up to about 125 miles an hour, while the barometric pressure dropped to 27.62 inches, the lowest ever recorded at a U. S. Weather Bureau station.

Hurricanes always originate, according to Dr. W. J. Humphreys, professor of meteorological physics at the Weather Bureau, in the doldrums, a region about ten to twenty degrees from the equator, which is characterized by relatively calm air. The Cape Verde Islands, where the Miami storm originated, are in this area; but hurricanes are not peculiar to the Atlantic Ocean, for the typhoons of the coast of China and the Philippines are similar, and they also occur in the Indian Ocean and, south of the equator, near New Zealand. However, those which occur south of the equator differ in an important respect from their northern counterparts, for while the air in the latter whirls in a counter-clockwise direction, the southern hurricanes whirl clockwise. This is an effect of the rotation of the earth. The exact cause of the whirls is unknown, but it is certainly not due merely to two winds in opposite directions happening to come close together, for such a whirl could be no greater than the relative motion of the two original winds. In a hurricane, wind velocities far in excess of any relative motion between opposing air currents are often observed. In addition to the whirling winds, there is an ascending current of air towards the center, which produces the torrential rains.

THE SCIENTIFIC MO

DECEMBER, 1926

SOME INTERESTING ANIMAL COMMUNITIES OF NORTHERN UTAH[1]

By Professor W. C. ALLEE
THE UNIVERSITY OF CHICAGO

A NUMBER of properly timed incidents determined the writing of this account. While the "Naturalists' Guide to the Americas" was in manuscript and the senior editor was urging all persons acquainted with areas worth describing to contribute short notes concerning them, the editorial office of this journal solicited an account of animal life that should be illustrated, interesting and not

[1] I am indebted to Dr. I. M. Hawley, Mr. Ralph King, Mr. Reed Christensen and Dr. Charles Rees, all formerly of the Utah Agricultural College at Logan, Utah, and to many others for assistance with field trips; to Mr. King and Mr. Christensen and Mr. David Hall, of Ohio State University, for access to their field notes; to Mr. Hall and to Mr. LaVell Cooley, of Logan, and others as acknowledged for photographs.

FIG. 1. CACHE VALLEY IN WINTER
WITH THE WELLSVILLE RANGE IN THE DISTANCE. THE MORMON TEMPLE AT LOGAN IS THE PRINCIPAL BUILDING SEEN. (COOLEY.)

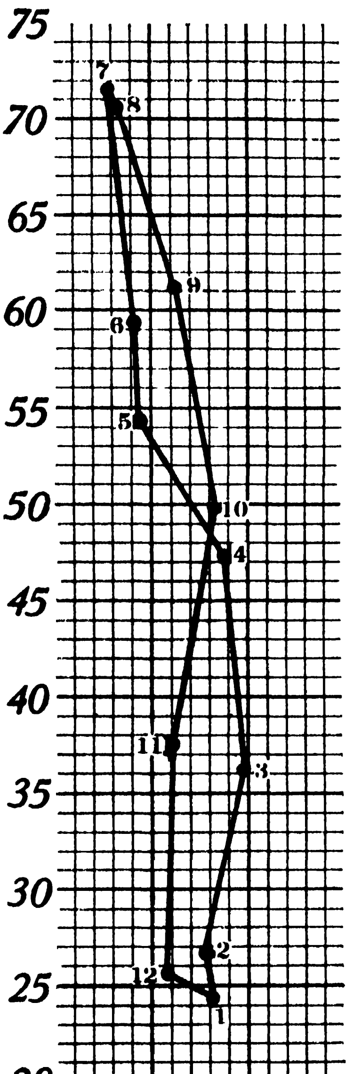


FIG. 2. A TEMPERATURE–RAINFALL CHART OF LOGAN, UTAH

BASED ON AVERAGES FOR THIRTY-ONE YEARS. THE ORDINATES GIVE MEAN MONTHLY TEMPERATURES IN FAHRENHEIT. THE ABSCISSAE GIVE MEAN MONTHLY RAINFALL IN INCHES. THE DATA ARE FROM U. S. CLIMATOLOGICAL DATA.

too technical. I had just spent two summers at my favorite relaxation of teaching zoology in a new region while exploring its zoological and scenic possibilities and had been supplied with numerous photographs by students and other friends. Finally zoological friends with vacations to plan, with or without automobiles, desired directions to interesting areas not too tourist worn and yet not too far from the beaten track of travel, where they might find some zoological stimulus as well as a western vacation.

Let all such, as soon as they can escape from classroom and laboratory, hurry west over the prairies and great plains while the June freshness still holds, if that be possible, cross the first ranges of the Rockies and turn north at Ogden either on train or the well-paved road. For headquarters they may well pass the cherry and peach orchards of Brigham City and, crossing the Wellsville Range, continue to the eastern side of Cache Valley where the flourishing city of Logan will furnish a civilized base from which a number of unique animal communities may be explored. While an automobile is a great aid in making the trips to be suggested, the ownership of a car is unnecessary.

The climate of the region may be understood from the accompanying graph of mean monthly rainfall and temperature given in Fig. 2, in which each month is numerically represented at the location which indicates the mean monthly temperature on the ordinates, and the mean monthly rainfall on the abscissae.

Cache Valley itself has been opened for trapping, exploration and settlement for a little more than a century. Despite the scanty rainfall, less than sixteen inches a year, and the great evaporation, seventy to eighty inches a year, the valley is well watered by rivers, irrigation ditches and artesian wells, so that the fertile plain, once the bed of old Lake Bonneville, is water-logged in places. Even among the cultivated fields the abundant yellow-headed blackbirds, sharing the swamps with their red-winged relatives, the long-billed curlews and an occasional egret, herons, hawks, ibises,

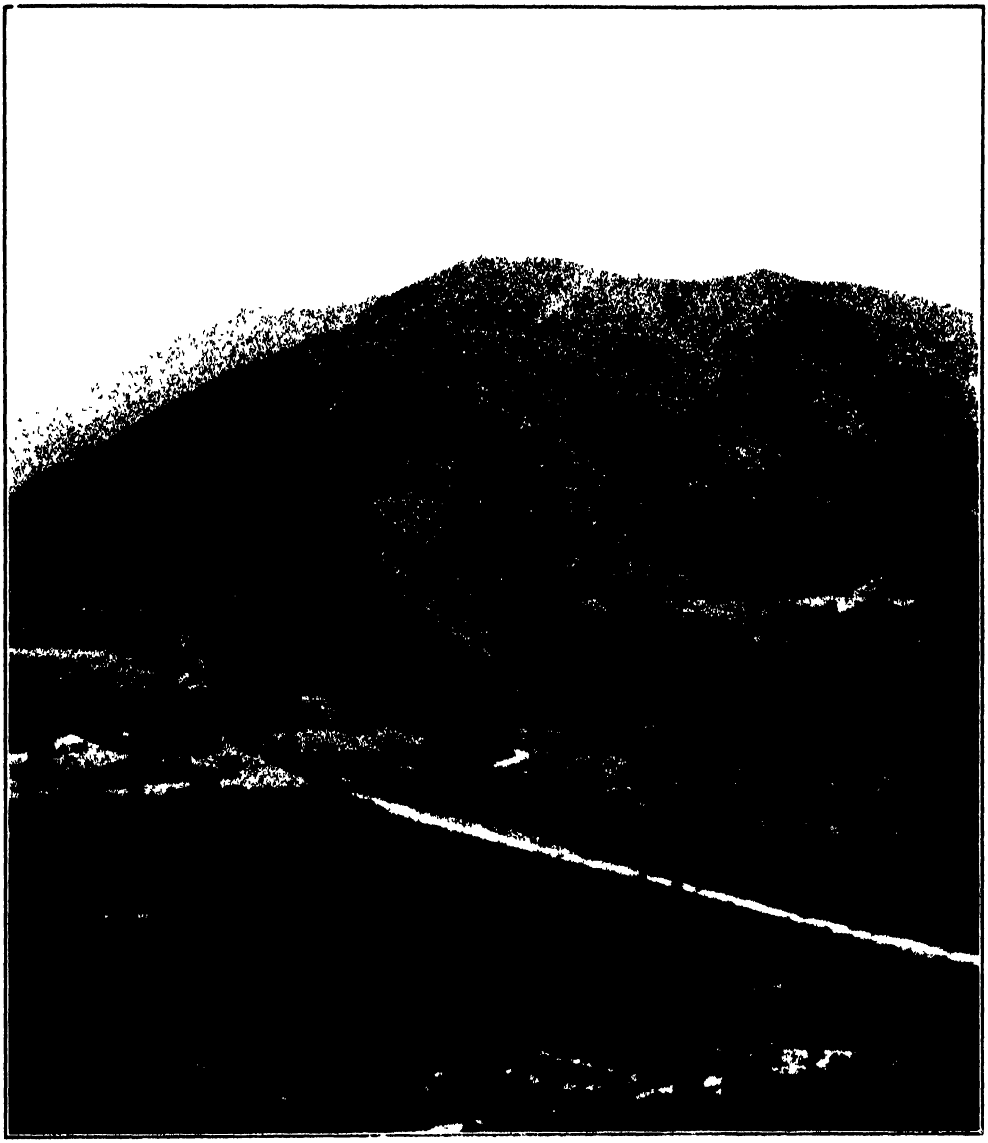


FIG. 3. LOOKING TOWARD MT. LOGAN
NOTE THE BEACH MARKS OF LAKE BONNEVILLE.

etc., remind one of the abundance of game and birds that must have greeted the early visitors to this valley.

The visiting naturalist soon learns that the distribution of these birds and of mammals is generally described in terms of Merriam's life zones which are locally recognized by the following trees which are used as "zone indicators":

Upper Sonoran:
  a. *Lower upper Sonoran*: Greasewood and sagebrush.
  b. *Upper-upper Sonoran*: Nut pine, broad leaved cottonwood, cedar.

Transition: Narrow leafed cottonwood, oak.

Canadian: White fir, blue spruce, aspen, Douglas fir.

Hudsonian: Engelmann spruce, sub-alpine fir.

Tundra: Bearberry.

If he remembers his zoogeography, the visitor will know that the life zones of Merriam were originally supposed to be plotted on a temperature basis; but since the exact yearly temperature ranges are hard come by in the field, these so-called zone indicators have been substituted, often without careful physiological work to determine the temperature relations of the indicators themselves.

When one starts to climb Mt. Logan (Fig. 3) by the excellent trail past the "Girls' Camp," (with these local zone indicators well in mind) he finds that the life zones are not the same on the two sides of the mountain. On the valley side facing west the sage brush, indicating "Lower-upper Sonoran," extended from the valley floor at 4,500 feet above sea level to the top at 9,713 feet, while on the eastern face this is soon superseded by the "Transition." The "Transition Zone" here is very narrow and is limited to the region near the stream which makes one question to what extent it is a temperature phenomenon. It soon gives way to the dense stands of Douglas fir and the beautiful aspen woods of the "Canadian Zone" (Fig. 4). One climbs through these and on through the Engelmann's spruce and the sub-alpine fir of the "Hudsonian Zone" only to come out above edaphic timber line into a good sage-brush association, indicating "Lower-upper Sonoran" when Alpine tundra was expected!

FIG. 4. THE ASPEN WOODS OF THE "CANADIAN LIFE ZONE"

Obviously something has gone wrong with the indicators. The temperature relations here, almost ten thousand feet above sea level, are decidedly different from those of the valley, as is shown by the mid-summer snow banks and the spring beauties and other vernal flowers blooming here long after they are past in the valley. The critically minded field naturalist with ecological training is likely to wonder if it would not be more scientific to describe these regions as sagebrush, aspen or Engelmann's spruce associations rather than to generalize them into the so-called life zones with their implied relationships between these mountain belts and the latitudinal belts of the eastern part of the continent.

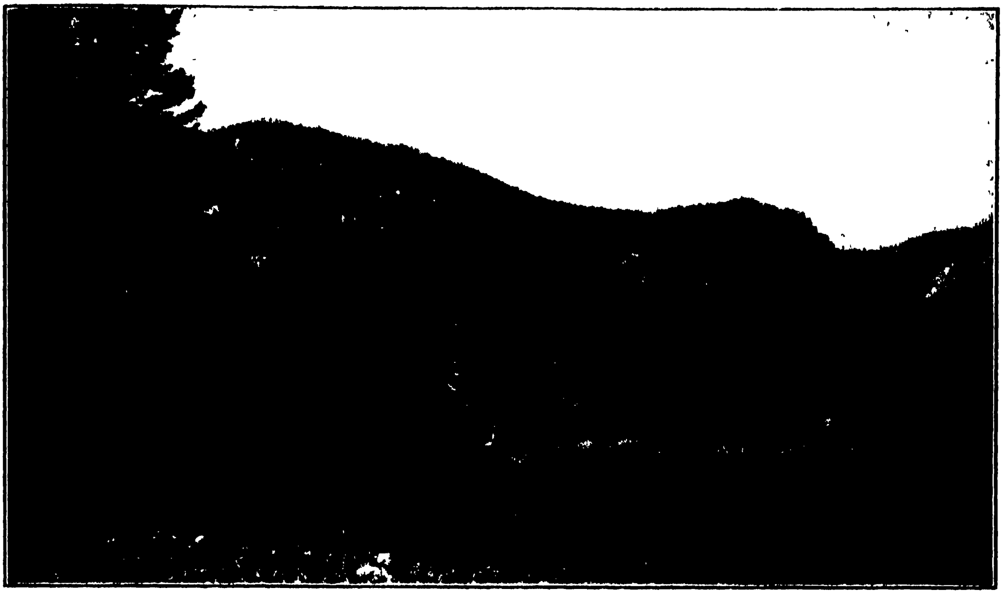


FIG. 5. "THE HUDSONIAN LIFE ZONE"
NOTE THE LIGHT SAGE BRUSH AREAS INDICATING "LOWER UPPER SONORAN" ON THE PEAK ABOVE.

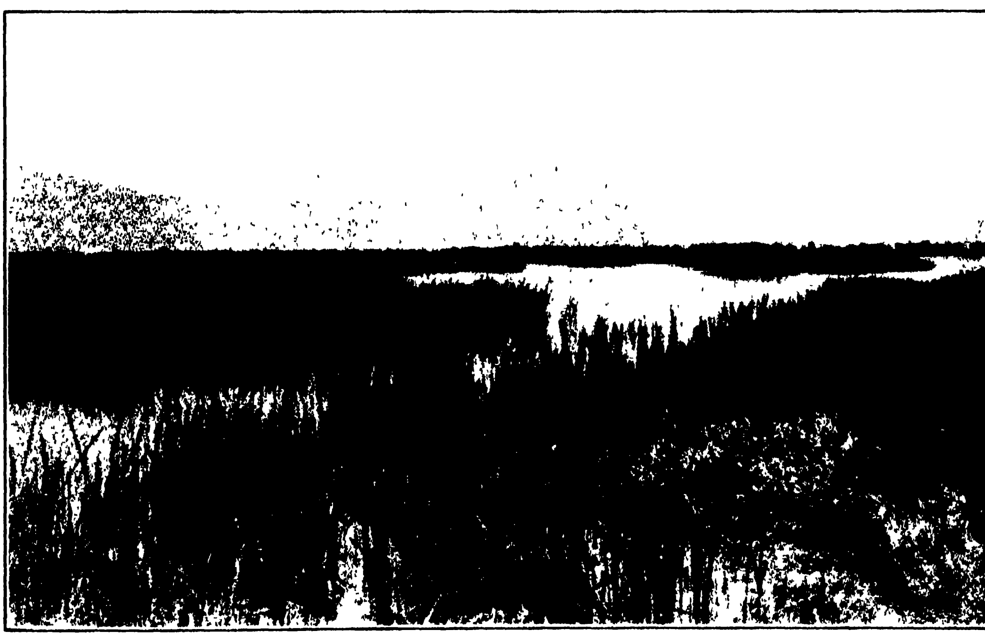


FIG. 6. LOOKING SOUTHEAST FROM DYKE. BEAR RIVER BAY. (COOLEY.)

FIG. 7. SNOWY EGRET
APPROXIMATELY THREE WEEKS OLD, JULY 3, 1925, BEAR RIVER BAY. (HALL.)

Further, one can but marvel at the potency of an idea in diverting attention from apparent facts when he considers the obvious correlation between moisture and plant and animal distribution in this region and the decidedly less obvious temperature relations. Yet the latter was chosen as the original basis of the life zone concept.

A number of mountain tops are available in easy trips from Logan as a center: as, Mt. Logan; Gog, Magog and Naomi; Ben Lomond and the Wellsville Range. None of these carries one above true timberline, since this would be found only at an elevation of 11,000 to 12,000 feet. These trips will take one into a wealth of broken mountainous country populated with elk, bear, porcupines, ground squirrels and the like. The game preserves include some 268,000 acres of the Cache National Forest.

Very occasionally on such climbs one finds small mountain ponds or lakes a hundred yards or so in diameter, at a height of 8,000 to 9,000 feet. These are populated in midsummer by a shrimp, *Branchinecta;* and by salamanders, *Ambystoma tigrinum,* adults and larvae; and by the toad *Bufo boreas.* In lower-lying ponds the apus-like *Lepidurus couesii* may be found in abundance.

Bear River Bay may readily be reached from the base camp at Logan by a few hours' automobile ride, providing arrangements have been made with one of the gun clubs or through the Brigham City Chamber of Commerce.

These extensive flats (Fig. 6), covering many thousands of acres, are largely held by private gun clubs. The caretaker of the Bear River Club, Mr. V. F. Davis, is an invaluable aid to the newcomer in this area. The flats are well known to sportsmen and have been the subject, recently, of a series of papers by Dr. Alexander Wetmore concerning the bird life with special reference to the duck sickness, which will be mentioned later. The region is much less known to teaching zoologists and to laboratory workers.

Bear River is the largest of three streams entering Great Salt Lake. It arises in Wyoming, drains into and out of Bear Lake (whose level is now artificially controlled), flows through Cache Valley and then through a narrow gorge into the Salt Lake Valley, at the outer edge of which, after forming an extensive delta, it breaks up into a number of branches before entering Bear River Bay of the Great Salt Lake. This is one of the great nesting and collecting grounds for western birds.

Arrangement can be made for staying at one of the numerous gun clubs and for transportation by suitable flat-bottomed boats. The visitor should be one of a very small party and should be prepared thoroughly for a demonstration of the abundance of mosquitoes as well as of ducks, ibises, herons and other birds.

According to Wetmore, eleven species of ducks and the Canada goose nest

FIG. 8. YOUNG AMERICAN BITTERN
BEAR RIVER BAY. (COOLEY.)

here. He estimates that some 15,000 ducklings come to maturity on these marshes each season. Other nesting birds are also abundant. Bitterns, great blue herons, egrets and snowy herons, black-crowned night herons, coots, Wilson's phalarope, avocets, black-necked stilts, sandpipers, willets, long-billed curlews, short-eared owls, marsh hawks, yellow-headed and redwing blackbirds, meadow larks and marsh wrens make their nests here, to mention only some of the more prominent. Finding nests is not arduous. The greater difficulty is to avoid stepping on eggs or on the nestlings while tramping through the short marsh grass or breaking through the canes.

Important as these flats are for nesting, they are equally important for molting, feeding and refuge grounds. The male ducks of most species nesting in this region do not stay with the female and the young (Wetmore says the ruddy drake is an exception) but soon gather in large flocks, coming from many other regions as well as from the local nesting grounds. On June 20, 1925, male pintail ducks had gathered near the opening of the south fork of Bear River so that the frightened flock which flew directly over us literally darkened the sky, as my father says wild pigeons in Indiana once did. In 1916 Wetmore found 130 pairs of breeding pintails on these marshes and as early as June 14 he records a flock of from 2,500 to 3,000 males having collected. Later in the season when shooting begins, even in recent years, shoveller

FIG. 9. MARSH HAWK'S NEST, EGG AND YOUNG
BEAR RIVER LOWLANDS ABOVE BEAR RIVER BAY. (COOLEY.)

ducks have been seen on the lake nearby in a bank two miles long and a quarter of a mile wide, busily feeding on the brine shrimp (*Artemia fertilis*) and on the larvae of pupa of the salt marsh fly, Ephydra.

One can not tramp these marshes near the close of the nesting season without being impressed with the prodigality of nature and with the loose adaptation of many animals to their environment. The thousands of birds in the air and on the ground must mean that the species are locally very successful; and this is indeed one of the great nesting marshes relatively untouched as yet by man during the nesting season, yet everywhere one sees dead nestlings, broken eggs, nests that have been flooded, others apparently deserted with only a partial clutch of eggs. The infant avian mortality is appalling and provides a great though wasted opportunity for avian social work!

An unexpected correlation between man's activities and the welfare of wild life has come to light in these marshes. For many years ducks have been found sick or dead in some numbers, but when the size of the colonies here was considered, these were not thought to be of great importance. However, in 1910 and the years following, the sickness became so widespread that the assistance of the United States Department of Agriculture was called in, and Dr. Alexander Wetmore spent three seasons in field studies with headquarters on these Bear River Flats. The seriousness of the disease and something of the abundance of the bird life of these marshes can be seen from the fact that Mr. V. F. Davis supervised the collection and burial of 46,723 dead ducks between September 7 and September 23, 1913. These were taken only from the open and Mr. Wetmore estimates that they represent only about 20 per cent. of the dead ducks on the flats. In other words, some 230,000 ducks died there in that one autumn from this illness.

Observations and experiments showed the illness may be caused by the chlorides of calcium and magnesium present on the alkali flats. That the disease did not appear as a plague earlier is to be explained from the rapid increase in land under irrigation, so that recently the stream flow has been markedly decreased during midsummer months. In fact, from July to September very little water flows out the mouths of the rivers entering Great Salt Lake, except from lower tributaries and from irrigation seepage. On these flats, frequently but an inch or two above water level, the alkali collects at the surface as the soil dries. The wind may drive water over these low-lying flats where it may take up the troublesome salts (along with NaCl). Such driven water would also carry a supply of seeds and bugs upon which birds might feed, taking water with the food and so obtain the necessary dosage of alkali salts. Rains would similarly form puddles containing the alkali salts. The subsoil here is strongly alkaline and there are plenty of the lethal salts available if a flow of fresh water is stopped.

When the height of irrigation ceases in the autumn, the illness tends to diminish rapidly with the new supply of fresh water. Dr. Wetmore found that the ailing birds will recover if placed where they can secure fresh water.

Apparently, by his industry in placing more and more land under irrigation, man is jeopardizing the life of this horde of wild fowl, since not only the ducks, but some twenty-five other species of Bear River birds are known to suffer from the malady. This is happening without industrial contamination or the physical destruction of the breeding grounds.

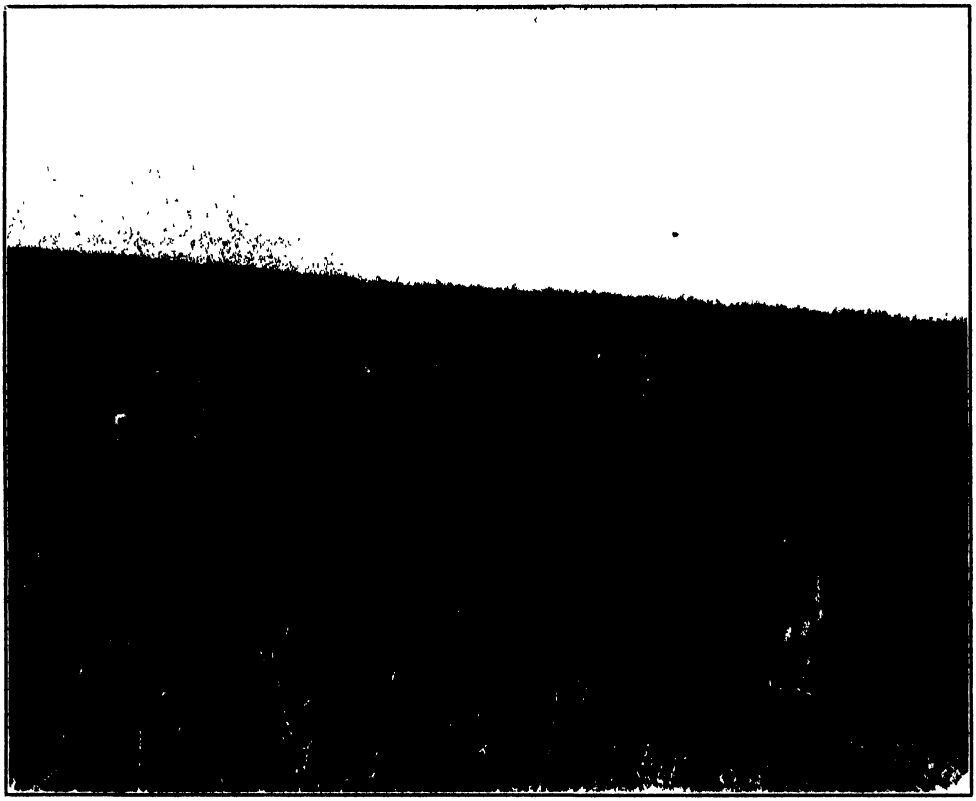


FIG. 10. BLUE HERON COLONY
BEAR RIVER BAY. (COOLEY.)

Many local observers do not accept Dr. Wetmore's explanation. They object that, with irrigation demands continuing to increase, the duck sickness should also increase yearly, which it is not doing. This may be explained in a number of ways. It may be that a partial temporary immunity has been gained by the great epidemic of ten to fifteen years ago; or that the birds have become acclimated to the new conditions in an average season; or the reported, but questioned, freshening of the water of Bear River following the completion of the Lucin Cut-off of the Southern Pacific Railway may have a saving effect.

Lead poisoning from eating the stray pellets of lead left after the shooting also causes sickness and death of many waterfowl. The pellets remain on the marsh for years and can readily be recovered from silt near the shooting blinds. Six No. 6 shot pellets experimentally fed to ducks were always fatal, and one might be.

At the Bear River Bay marshes one comes in contact with the brackish waters of Great Salt Lake—now well upon the marshes, and again only out at the mouths of the channels, depending upon the season and the strength and steadiness of the wind. Closer contact with the animal life of the lake may well be deferred until arrangements have been made to visit Hat Island, the nesting ground in mid-lake of gulls, great blue heron and white pelicans. Such arrangements may be made for a consideration with the Southern Pacific Railroad. A party of fifteen or more

are able to make the trip very reasonably and within a day's time. The through train stops at Colin in mid-lake on the Lucin Cut-off, and a Southern Pacific Railway launch will carry a party twelve miles south to Hat Island. The island is approximately twenty-one acres in extent and rises in the center of Salt Lake about seventy-five feet above lake level. The underlying rock is of Pre-cambrian glaciated schist, containing granite boulders, as can be seen in Fig. 11.

On the cut-off trestle and about the boats are a large number of spiders, which obviously feed on the swarms of Ephydra, or brine fly, whose abundance as imagos on the surface and near the water have been described by Aldrich. Despite this description one needs to watch the motor boat plough through the heavy brine, stirring up the brown mass from the surface, and see this mass break into myriads of small brown flies that get into nostrils and mouth in spite of every care, to realize how thick flies can be.

Tow nets or dip nets towed overboard through the brine bring in numbers of the Ephydra larvae (three species have been described) and pupa in their cases, along with the brine shrimp, *Artemia fertilis* Ver., which is found in numbers all along from the trestle during the two hours' run to the island. One of the Corixidae is also found in the lake, but less abundantly. Vorhies also lists a number of Protozoa, including Amoeba. Through the clear water a greenish growth could be seen. F. P. Daniels summarizes the plants reported in 1917. He found two species of Chlamydomonas, two diatoms and one of blue-green algae (*Aphanothica packardii*) in the region near Salt Lake City. The last occurs in considerable masses.

Dr. V. E. Shelford reports the hydrogen-ion concentration of Salt Lake at Salt Air to be pH 8.1. My own determinations in mid-lake show uncorrected

FIG. 11. GULLS ON THE PRECAMBRIAN GLACIATED SCHIST OF HAT ISLAND. (COOLEY.)

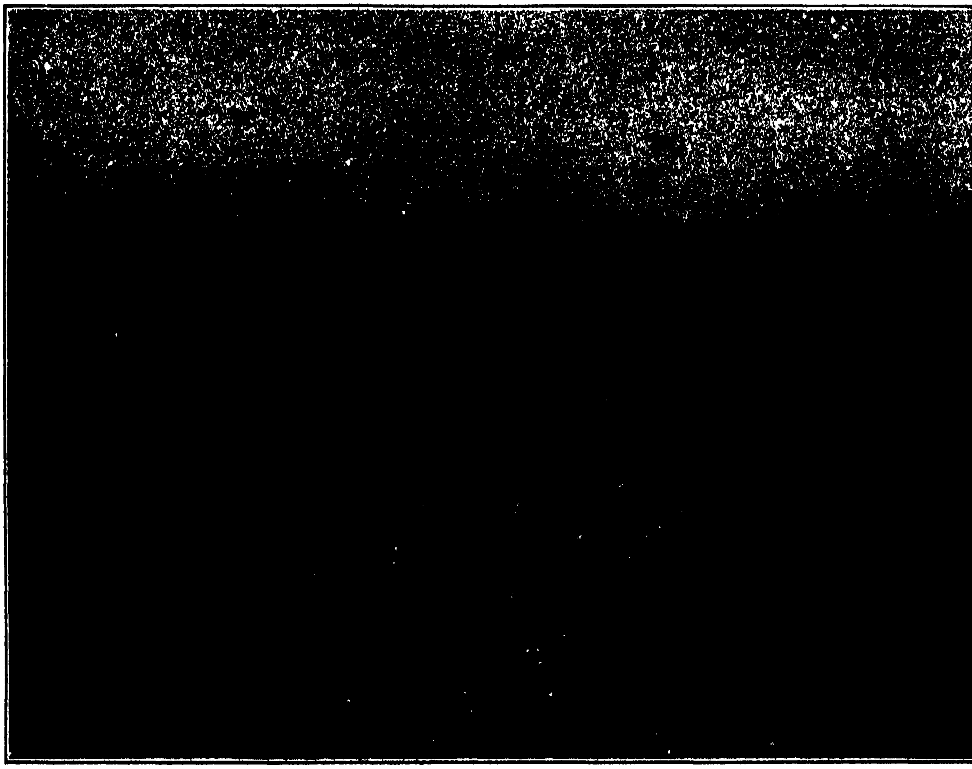


FIG. 12. CALIFORNIA GULLS AT HAT ISLAND. (TANNER.)

readings with phenol red of pH 8.3. Just what the salt error may be, I do not know. The brine is 23 per cent. salt.

The swarms of gulls—nestlings, yearlings and full-plumaged—found on and near the island are well worth the visit (Figs. 11–12). Any doubts of the ability and willingness of the gulls to get salt water in their mouths last only until one throws a test bread crust overboard. Regurgitations of *Ephydra* cases on the island show that the larvae and pupa of the brine fly are used as food. Doubtless the abundant brine shrimps are also eaten.

In addition to the gulls we found young of the white pelicans and nests of the great blue herons on the island. Palmer (1915), visiting the island in mid-May, about two months before the time of our visit, found both California and ringed billed gulls to the number of about 15,000 to 20,000, about 2,000 of the white pelicans, about 400 great blue herons, a small colony of Caspian terns and one killdeer, apparently a chance visitor. Our estimates ran much higher for the gulls and about the same for the pelicans.[2]

The great low-lying nests of the great blue herons (Fig. 14) attract the attention of the easterner, who has been used to see such nests only at the top of tall trees. The twigs with which they are made have been carried for the most part from the mainland just as the food of the nesting birds also comes mainly from the swamps, lakes, rivers and fields of the mainland. The young pelicans are easily rounded up into close droves (Fig. 15). Many of them when excited

[2] Dr. Charles G. Plummer, of Salt Lake City, has made extensive studies of the birds on Hat Island which are not yet in print unfortunately.

FIG. 13. GULLS NEAR HAT ISLAND. (TANNER.)

regurgitate their food, and on examination of one bird's dinner deposited at my feet I found this story could be reconstructed.

Early in the morning of July 5, 1924, a young small-mouthed black bass was feeding in the fresh waters of one of the mainland streams and had half swallowed a smaller minnow. His rush after food brought him within range of a feeding pelican and he was gobbled down along with his half-swallowed prey. When several more fishes had joined this one, the pelican, probably in company with a small group of others, rose clumsily from the water and made its way in V-formation back to the nesting grounds on Hat Island. There a young pelican persuaded this particular bird to allow it to feed from the fish which had been completely swallowed and the bass with its half-swallowed minnow were transferred from the stomach of one pelican to another. Later, when we came on the island, the youngster in his excitement presented the slightly digested fishes to us and, as we turned away after a careful examination, the greedy gulls were again gobbling the much-swallowed fish. I can not be sure that this was its last esophageal journey, for the young gulls were also regurgitating in their excitement at our approach, and this bass with its half-swallowed prey may well have come up and down once more before falling to pieces.

In addition to the birds we found the following animals on the island: dragonflies, Libellulidae; ground beetles, Carabidae; flies, Muscidae, Ephydra; Dermestid beetles (two species, adult and larvae); Circulionid beetles; spiders, Dysideridae; wasps, Specidae; the western harvester ant, *Pogonomyrmex occidentalis;* Geometrid moth larvae, and the lizard called the desert race runner (*Cnemidophorus tessellatus tessellatus*). In addition there were a number of biting bird lice, one colony of which was found almost completely lining the pouch and gullet of one of the young pelicans. It is interesting to note that Palmer in 1915 records seeing one species of lizard on the island.

The region near Great Salt Lake is shown on even the more conservative maps as desert country, but green fields, great swamps and a sagebrush-covered island all crowded with animal life do not fit the usual picture of desert life. True desert conditions are nearby. One finds that the western part of Promontory Ridge, which looks down on the teeming Bear River Bay marshes, has only ten inches of rain or less per year. One of the characteristics of life of the region is the sudden transition from one animal habitat to another.

In order to reach the Salt Lake Desert region, which has less than five inches of rain a year, one should travel by automobile or train through Salt Lake City to Knolls, about eighty miles west of Great Salt Lake on the transcontinental automobile road, which we shall hope is now improved out of the axle-deep ruts filled with fine dust that characterized it a year ago. Here are two types of desert: the lifeless alkali flats, and the adjoining sand dunes where life is more abundant.

FIG. 15. THE ROUND UP OF YOUNG WHITE PELICAN.

FIG. 14. BLUE HERON'S NEST ON HAT ISLAND.

There a brief search gave us the western harvester ant; two dragon flies, Libellula and Epiaeschna; numerous Lycosid spiders; robber flies, Asilidae; adult ant lions, Myrmeleon; darkling beetles, burrowing in the sand; solitary wasps, Specidae; tiger beetles, Cincindellidae; four species of grasshoppers; one praying mantis; two lizards, the desert race runner (*Cnemidophorus tessellatus tessellatus*) and the sage swift (*Sceloporus graciosus*); the coyote and a species of Lepus.

Other interesting animal communities available from headquarters near Logan include those of Bear Lake, a beautiful mountain lake some seventeen miles long and eight miles wide, about 6,000 feet above sea level, with an extensive swamp at the north end, and with a small hot

water spring nearby. There is the extensive Logan Cave on the route to Bear Lake. In Idaho, within a day's run by automobile, one may find lava beds at the "Craters of the Moon." One may find planarian watercress swamps, small alkali flats, extensive areas waterlogged from irrigation, together with the expected mountain brooks with their excellent supply of stocked trout and associated animals.

The problems arising from a consideration of the animal communities of the region are numberless. The obvious economic ones are being attacked, but many of the underlying biological problems are untouched as yet. There is a vast need of studies in taxonomy, particularly among the insect groups. A great many of the specimens collected are new species or new varieties. Thus Dr. Annette Braun collected microlepidoptera in this region for six weeks in 1924 and obtained thirty-six new species and one new genus out of one hundred and fourteen species on which she reports. It seems a pity that the interest has shifted so far from taxonomy that much of this basic work remains untouched in the western country. When species are unknown, it is obvious that the ecological relations of many species are unsuspected. In a region offering such sharp lines of demarcation between different animal communities one has an unusual opportunity for profitable study of the operation of environmental factors in limiting distribution. Topographic, climatic and soilic transitions are sudden and extreme. Such analyses obviously call for modern instrumental studies as well as the older and always necessary studies of biological relations.

It is important to record that the rural and city population of the region are unusually interested in the results of biological investigations and are sympathetic and ready to be helpful in furthering such work. This is in part due to their recognition of the dependence of the agriculture and mining of the region upon scientific aid.

With a fairly extensive field experience with different types of animal habitats, I know of no other region possessing so great a variety of animal communities within so short a range, and I have never seen in nature such a demonstration of the primeval abundance of animal life on land. The fact that nearby there may be an almost absolute dearth of animals only makes the abundance more dramatic. The availability of this region for an interesting summer excursion for biologists is by no means lessened by its proximity to the Jackson Hole country and Yellowstone National Park on the north and to the spectacular Cedar Breaks and Bryce's Canyon region to the south.

THE RIDDLE OF LIFE

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THERE are probably few individuals who have lived to the age of understanding without asking at least themselves the questions: What is life? From whence does it come, and how does the living differ from the lifeless? These have been riddles of the centuries. The philosophers have pondered over them. The scientists have taken to their laboratories in an endeavor to wring from nature an answer. From the very dawn of history we find that all mankind has concerned itself with these momentous questions, and to-day some will say that they are no nearer solved than when primitive man strolled from his cave, club in hand, to slay the living that by so doing he might live. Be this as it may, contrary to the belief of many, the search has yielded a harvest rich indeed. It is the history of this harvest and some of its fruits which we wish to examine briefly.

The race is like the child in that during the early stages of development the imagination is the predominating instinct; hence we find the first descriptions of the origin of life highly imaginative. The ancient Greeks looked on the Goddess Gea as the mother of mankind. In their glorious mythology they pictured men and women as springing into life from the stones cast on the earth. The Celts pictured the soil as peopled with gnomes and pixies, friends or foes of mankind. Many ancient writers fancifully portrayed the transformation of dead into living matter. The Greek philosophers taught it. Aristotle wrote in 384 B.C.: "Animals sometimes arise in soil, in plants or in other animals."

Three centuries later Ovid, in his dissertation on the Pythagorean philosophy, defends the doctrine of spontaneous generation, whereas Virgil in his Georgics gives directions for the artificial production of bees.

Paracelsus (1492–1541), a Swiss medical philosopher who greatly confused fact and fancy, gives instructions for the making of Homunculus. Certain substances are to be placed in a bottle; the bottle is well stoppered and burned in a manure heap. Every day certain incantations are pronounced over the bottle. In time, so Paracelsus declares, a small living human being (homunculus) will appear in the bottle. He naïvely admits that he never succeeded in keeping the little man alive after it was taken from the bottle. Kircher went a step farther and describes and even pictures certain animals which he claims were spontaneously produced before his very eyes, through the action of water on fragments of plants.

During the middle of the sixteenth century Cardano thought that water gave rise to fish and other animals and that water was the cause of fermentation. An Italian, Bononani, tells of a wonderful transformation which he claims to have witnessed. Rotten timber which he rescued from the sea produced worms; these gave rise to butterflies; and strangest of all the butterflies became birds and flew away. Gradually these grotesque fanciful opinions concerning the origin of life were abandoned, and it was believed that only the lower plants and animals, seaweeds, algae, lichens, lice, mites and maggots could develop spontaneously. Even to-day we find

fairly intelligent individuals who believe that mites and lice can develop without parents and that the hair from the tail or mane of a horse will change into a worm or snake if placed in water and exposed to light and warmth.

Every one took it as a self-evident fact that maggots originated spontaneously from decomposing meat or cheese, until an Italian poet and physician, Redi (1626–98), took the simple precaution of screening the mouth of jars containing meat so that flies could not enter. They were attracted by the odor and deposited their eggs on the gauze, and it was from these that the so-called "worms" arose.

By the middle of the seventeenth century the theory of the spontaneous generation of mice, scorpions and maggots had been proven untenable. But at this time Leeuwenhoek discovered various living moving animalcules in raindrops, saliva and many putrefying substances.

Then all were sure there had been discovered the origin of life. For any one provided with this new instrument, the microscope, could easily demonstrate for himself the spontaneous generation of microscopic eels in vinegar or produce myriads of different and interesting creatures in simple infusions of hay or other organic material.

Needham, a Catholic priest, in 1745 placed decaying organic matter in a closed vessel. This he placed on hot ashes to destroy any existing life. On examining the contents of the vessel after a time, he found micro-organisms which were not there in the beginning. From this he evolved his theory that a force called "productive" or "vegetative" existed which was responsible for the formation of organized beings. The great naturalist, Buffon, elaborated the theory that there were certain unchangeable parts common to all living creatures. After death these ultimate constituents were supposed to be set free and become active until with one another and still other particles they gave rise to swarms of microscopic living creatures.

In 1769 Spallanzani repeated the work of Needham. He boiled the material for one hour and kept it in hermetically sealed flasks. He wrote: "I used hermetically sealed vessels. I kept them for one hour in boiling water, and after opening and examining their contents, after a reasonable interval, I found not the slightest trace of animalcules, though I had examined the infusion from nineteen different vessels."

But the believers in the theory of spontaneous generation were not convinced, as they claimed that the boiling had altered the character of the infusion so it was unfit for the production of life. Voltaire, with his characteristic satire, took up the fight at this point and ridiculed the operations of the English clergy "who had engendered eels in the gravy of boiled mutton" and wittily remarked: "It is strange that men should deny a creator and yet attribute to themselves the power of creating eels." This, however, was a controversy to be settled not by ridicule but by experimental evidence.

Spallanzani answered their objections by cracking one of the flasks. Air entered and decay immediately set in. Even this was not sufficient to overthrow an age-long belief. The abiogenist argued that "the sealing of the flask excluded air and the oxygen of air is essential for the generation of life."

This objection was answered by the work of many an ingenious investigator. Schulze in 1836 passed air through strong acids and then into boiled infusions and failed to find life even after the infusion had stood some time. Schwann passed the air through highly heated tubes with the same results. To this the argument of the opponents was, "heat and chemicals so alter the physical and chemical composition of the air

that it is unable to engender life." The work of Shroeder and Dusch (1853) was more convincing, for they found that it is sufficient to stopper bottles containing heated milk, meat and other perishable substances and they will keep indefinitely.

Even this was not sufficient to overthrow the belief in spontaneous generation, for as late as 1859 Panchet revived it in a book in which he heaped experiment upon experiment and argument upon argument spiced with the logic and sarcasm of the man of science in favor of spontaneous generation. He was opposed by Pasteur, who collected the floating particles of the air surrounding his laboratory in the Rue d'Ulm and subjected them to microscopic examination. He sowed them in sterilized infusions and obtained abundant crops of microscopic organisms. He showed that the cause which communicated life to the infusion was not uniformally diffused, but in the workshop and crowded streets of Paris living organisms were numerous, whereas on the tops of high mountains and glaciers the air is usually free from life. He showed that beef tea sterilized in flasks with the neck bent like that of a swan did not spoil, even though exposed to the atmosphere. As late as 1922 there was exhibited in the United States one of those flasks of beef tea which it was claimed Pasteur had prepared over fifty years before; it was still clear and free from life.

In the spring of 1864 nearly all Paris was at one of Pasteur's lectures in which he portrayed vividly and with a touch of scorn for his adversaries his conclusion concerning the origin of bacteria. He said: "There is no condition known to-day in which you can affirm that microscopic beings come into the world without germs, without parents like themselves. They who allege it have been the sport of illusions, of ill-made experiments, vitiated by errors which they have not been able to perceive, and have not known how to avoid." Then in a passage of singular beauty he described himself watching and imploring his flasks to give him a sign of life, but they would not, "for I have kept from them, and am still keeping from them that one thing which is above the power of man to make; I have kept from them the germs which float in the air; I have kept from them life."

Thus was established the principle that life springs only from life, from the viewpoint of the welfare of the human race the most momentous discovery made by man, for on it is reared those three sciences which have done so much to prevent, alleviate and cure human ills—bacteriology, pathology and surgery.

To-day we can only speculate as to the origin of life on this planet. The most outstanding theories can be summarized as follows:

Vitalism had its champions for ages and reached the heyday of its power in the eighteenth century. It assumes that an all-controlling, unknown and unknowable mystical and permechanical force was responsible for all living processes. Such a postulate carries the subject beyond the realm of scientific investigation and as here laid down is not generally held by the thinkers of to-day.

All experiments performed by man and those occurring naturally and studied by man invariably point to the conclusion that life always springs from life. This has caused many serious thinkers to ask, "Is not life as old as matter itself and is carried from planet to planet?" Some bacterial forms will lie dormant for years and stand temperatures as low as 250 degrees C. Hence Arrhenius suggests that life is driven from planet to planet by light waves, and finds lodgment and grows wherever conditions are appropriate. Such a

hypothesis removes the question from this to some other sphere beyond the reach of man and does not satisfy the inquisitive mind; hence various other theories have been formulated which try to account for its formation on this earth. In all these it is assumed that the various changes occurring in the cooling and reacting earth gave rise to molecules endowed with life. All are ingenuous but speculative and loudly proclaim the need of a future Darwin with a mind great enough to sweep the whole universe and formulate for mankind a fruitful working hypothesis. In the meantime, man accepts the dictum that life springs only from life and divided the objects on the earth into the two great classes—the living and the lifeless. The former possess certain characteristics which are not possessed by the latter. These properties are movement, growth, reproduction, respiration and irritability. It is to a study of these that the scientist has turned his attention during the last quarter of a century.

Lifeless matter often manifests movement. A rock, cut from the side of a mountain, rolls into the valley below. Movement is due to position. The migration of the amoeba may be closely imitated with a drop of chloroform placed in water on a superficially hardened shellac surface. A marked surface tension develops between the chloroform, the water and the moist shellac layer; soon the chloroform and shellac commence to be moistened at some point, and at this point the surface tension of the chloroform is lowered and it seeks to spread itself out. By various modifications of this method one can imitate the chasing of small amoebae by larger ones, the taking up of food and very many interesting life phenomena. In all these imitations, however, it is to be noted that the impelling factor comes from without, whereas in the living cell it comes from within. This may manifest itself as the change of position on the earth's surface, as in the case of the animal or the internal protoplasmatic movements of the plant cells. While much of this may be due to osmotic changes of the protoplasm, yet the energy comes from the food, and in this the law of conservation of energy has been found to rigidly hold. From it we are learning that the efficient engines for the transformation of energy are not man-made but the natural living cells. And although in this respect the body of man is wonderful, yet the little firefly we observe darting about on a dark summer evening is probably the most efficient dynamo in existence.

Growth, yes, lifeless material grows, as even the young boy understands as he rolls his snowman. A lump of copper sulfate thrown into a dilute solution of potassium ferrocyanid soon develops a brown envelope which throws out upward-growing runners, and in half an hour's time the fluid is filled with figures which vividly recall both the shape and color of the seaweed. The weight of the resulting artificial plants may be 150 times that of the original copper sulphate. We all know that a crystal placed in the mother liquid grows. This has been likened unto the growth of the living organism, but only a moment's thought is necessary to show that the likeness is only superficial. Crystals grow by the addition of a like material, whereas the living cell takes dissimilar substances and transforms them into another material: living tissue.

Inasmuch as growth viewed from the physiological viewpoint consists of the transforming of unorganized foodstuffs into new chemical entities which constitute the organized protoplasm of the animal, it is evident that the living organism must have food. It is but a short time since the rule was that the food of man should contain carbohydrates, fats, proteins and water. Ash was looked upon more as an impurity which was

tolerated but not essential until it was found that an animal on such a diet died sooner than another receiving only water. Ash then was found essential not alone as building material but as a regulator of body processes, and some even claim that life phenomena function even more through the mineral elements than through the organic. To-day we know that a diet consisting of carbohydrates, fats, proteins, ash and water will not maintain growth unless the growth-promoting Vitamine B is present, and even then for only a short time unless the regulatory Vitamins A, C and D are also included in the diet. Nor is the kind of protein without significance. The growth-promoting lysine and the regulatory tryptophane must be contained within their molecule.

The diet may meet all these requirements and still there be no growth even in the young animal, or when there is growth it may be abnormal, as in the case of gigantism, acromegaly and myxedema, when there is an abnormal functioning of the endocrine organs. The results which have been obtained in transforming the cretin into a normal individual is a metamorphosis as wonderful as the transforming of the tadpole into the frog. Gudermasch made the remarkable discovery that even this metamorphosis, which in our climate usually occurs during the third or fourth month of life of the tadpole, can be brought about at will even in the youngest tadpoles by feeding them with thyroid gland—no matter from what animal. By feeding very young tadpoles with this substance frogs no larger than a fly can be produced. Allen added the observation that if a young tadpole is deprived of its thyroid gland it is unable ever to become a frog and it remains a tadpole, which, however, can reach a long life and continue to grow beyond the usual size of the tadpole. However, when such abnormal tadpoles are fed with thyroid they promptly undergo metamorphosis. Similarly, the products of the endocrine organs govern the nature and rate of growth.

The size which the individual reaches is not alone determined by inheritance and the food received but also by the activity of the pituitary gland. For to-day in animal experiments there is produced at will the giant or the pigmy by the use of tethelin. These discoveries have placed in the hands of the dietitian and physician weapons against abnormalities of growth in stature and in mind which in the age of mythology were attributed only to the gods.

In man there are periods of rapid growth followed by quiescent periods. These are three in number, each beginning with a period of relatively slow growth, followed by a period of very rapid growth and culminating with the termination of the cycle in a period of slackening growth again. In the case of the first two cycles this slackening of growth is followed by a fresh spurt of acceleration due to the succeeding cycle. The first cycle closes toward the end of the first year, the second about the sixth year and the third at maturity. It has been recently shown by Robertson that these cycles of growth obey the equation of an autocatalyzed monomolecular reaction.

The third characteristic of the living, and the only property it is certain that some of the simpler organisms possesses —organisms too small to be seen with even the most powerful microscope—is that of reproduction.

Although the morphological changes occurring in multiplication have long been studied, it is only recently that successful attempts have been made to study that first stage of reproduction—fertilization. The work of Loeb on the egg of the sea urchin or frog has demonstrated that they may be successfully fertilized by treating first with a dilute solution of

butyric acid and then with hypertonic sea water. When thus treated the unfertilized egg develops into the adult possessing maternal characteristics. This called forth from the laity the statement that life had been created, but the answer from the scientist came, "No, life has not been created. There has only been arrested a chemical process which has its origin with the origin of the cell and which ultimately ends in the death of the organism." To test this proposition the unfertilized cell was treated with antiseptic strong enough to retard enzymic action but not strong enough to kill the cell, and even the unfertilized cell developed for some time. Moreover, Loeb found that the duration of life, barring accidents and disease, in the metazoa, is inversely proportional to the temperature at which that animal is living. Decrease the temperature ten degrees and one doubles or trebles the length of life. Or, in other words, living matter within certain limits obeys the temperature law of van't Hoff and Arrhenius.

If certain salt-water fish be placed in a solution of common salt having the same osmotic pressure as has sea water the fish soon die. Death in this case is not due to a lack of food, as a similar fish placed in distilled water lives for some time. Now, if a small quantity of calcium chlorid had been added to the first solution the fish would have lived. Moreover, if the heart be removed from the body of an animal and placed in a salt solution it soon dies, but if small quantities of calcium salts be present the heart beats normally. Now, the tissues of the animal are all bathed during health in a solution having a balanced composition, but in some diseases this concentration is changed. Hence, we have abnormal function, or even death. This plays a part in many nervous disorders. Probably it is often the prime factor in chorea, or even some tumorous growths may have their origin in some such fashion. Moreover this discovery explains the action of many of the common cathartics on the human organism. Inasmuch as they are calcium precipitants, they leave an unbalanced condition in the protoplasm—hence, the increased muscular contractions.

The same laws hold in the unicellular and multicellular animals, that is, they must not only have sufficient mineral food, but it must be in the right proportion. Hence, when viewed by themselves, the experiments on the fertilization of the egg appear trivial, but from them has been developed this fundamental law—"Normal life is possible only when necessary salts combine with the colloids of living substances in a definite ratio."

Finally, we have two other properties of living matter—respiration and irritability—which often require special apparatus for their detection but which are just as fundamental as the others. All living things respire and consume oxygen, liberate energy and give off carbon dioxide. This is obvious in the case of man, but not in the case of the potato; but allow water to find its way into the potato pit, and the potatoes are drowned, as man would be. Two kernels of wheat side by side appear the same—one is alive and will grow if placed in suitable soil, the other is dead and will not grow. The two seeds placed in the chamber of a biometer show unmistakable differences in the quantity of carbon dioxide production.

Both the living and the dead seed gives off carbon dioxide, the differences being only in quantity. The living cell, however, is markedly different from the dead in that it is irritable. Prick a man with a pin and he jumps and says, "Ouch," or he may even use stronger language. Prick the living seed with a pin and it also jumps and says, "Ouch," but in language which it requires the

biometer to detect and interpret. It gives off more carbon dioxide. This is true of all cells, even in the nerves which many seem to think obtain their energy from some other source than the metabolized food. This property of increased carbon dioxide output and irritation is so general that it has come to be spoken of as "a chemical sign of life." And by following this gaseous exchange in the higher animals it is possible to determine whether carbohydrates, fats or proteins are being burned, or whether one is being transformed into one of the others.

For years all these transformations were explained by the statement that they were "cell activities." But refined chemical and biological methods have made it possible to push aside the mantle surrounding the cell and to gather some of the engines with which life acts. And to-day many scientists are busy studying these engines—the enzymes. At first attempts were made to obtain the purified product, but, inasmuch as we have no criterion by which purity can be judged and further because of the extreme unstability of the product, the work is extremely difficult. Efforts, therefore, are being made to synthesize the enzymes and to learn the laws governing their activity.

Advances have already been made. Euler has produced an artificial oxidase, Falk an artificial lipase. The synthesis and control of artificial enzymes will revolutionize the science and art of organic synthesis. It may make it possible to control or combat pathological conditions in the human organism.

All the vital steps in digestion are due to enzymes. When they fail, due to disease, will it be possible to replace them by the laboratory product? This is being done in the case of the diabetic who has lost his power to oxidize sugar. He is being given insulin which replaces the product which he can no longer synthesize, and the unfortunate individual is being saved from a living death. The sugar-beet by means of its leaves gathers carbon dioxide and kinetic energy. Through its roots it drinks in water. In the cell they are transformed into sucrose. Some time in the future will the sugar factory be a place in which carbon dioxide of limestone through the intervention of catalysts is made to combine with water, thus producing formaldehyde, which on condensing yields sugar?

Having synthesized the carbohydrates, why not the fats, and finally the proteins, and thus the laboratory in place of the field become the source of the food of man? This I grant is imaginary and to-day sounds like a dream. But we must remember that synthetic alazarine red and indigo blue have replaced the natural products from the madder and indigo plants. Camphor no longer comes only from the camphor tree. The synthetic perfumes are destroying the flower industries of Italy and France. Cocaine has been replaced by the synthetic product, procain, which possesses all the anesthetic properties of the natural product and is devoid of its toxicity. Synthetic products bid fair to accomplish in the case of pneumonia, tuberculosis and cancer what salvarsan and quinine are doing in the case of syphilis and malaria. To-day it is possible that a synthetic drug will conquer that horrible plague, leprosy. Hence, it requires a vivid imagination to even portray the possibilities of the future.

We have seen how rich has been the harvest from a functional study of the living cell. No less interesting and remunerative has been the structural study. All recognize that there are no two men exactly alike. The cattleman tells us that he has no two cattle alike, the sheepherder that there are no two sheep alike, the botanist that no two leaves or blades of grass are alike, and

now the biologist tells us that the proteins composing our tissues are different from those composing the tissues of other individuals. Our individuality goes back to each individual cell. True, they are composed of the same amino acids, but these are arranged in different combinations. Now, from the nineteen amino acids could there be produced enough different proteins for all? Calculating the theoretical number of permutations and combinations we find there to be no less than two million billion different proteins. These, while the stream of life is coursing through the living cell, are held in a certain labile position. When death comes they swing back to the stable.

Throughout the study of the living cell one is impressed with the order, the correlation, the smooth and compact way in which the reaction goes on in the living cell in opposition to the many imitative methods of man. One example will make this clear. Man fixes nitrogen by means of a gigantic arc light in a chimney through which a current of hot air is blown. The flaming disk has a diameter of seven feet and reaches a temperature in the neighborhood of 6,300 degrees F. The product dissolved in water gives us nitric acid. In another method air is cooled to —194 degrees C., the nitrogen boiled off, mixed with hydrogen in the proportion of 1 to 3, heated to a temperature of 1,300 degrees C., and then passed over finely divided uranium. There results ammonia. Thus, in synthetic processes great variations in temperatures and huge, complicated, expensive apparatus are used.

When the bacterial cell fixes nitrogen there is also a real conflagration in which plant residues act as the fuel and the bacterial body the furnace. But how different are the two! The living cell is 90 per cent. water and weighs only one two-hundredth million of a milligram. It works in the dark, damp, warm soil and generates little heat and no light. It produces not simple nitric acid and ammonia but the highly complex proteins.

This living cell is an engine which not only does its work, but it repairs its own wornout parts. It works by means of enzymes. The reactions of each are accurately timed to meet the reactions of all the others and to meet the requirements of the living cell. Old protoplasm is torn out, new is made to take its place. The carbohydrates and fats are systematically fragmented so the energy is nicely liberated to meet the needs of the living organism. However, when the master of ceremonies, life, departs, each works independent of the others. They pull and they tear until they destroy their very home. It is as if they are vying with each other to see which can do the most damage.

"And now to-day in the electron of the atom and in the germ cell of living protoplasm, we have at last come upon God in his workshop and exclaimed, 'It is all machinery!' The spiritualist has said, 'Behind it is the breath of God!' One has found a universe that works, the other a universe that is significant. One has found the tools; the other, the workman. But whether he be a mechanist or vitalist, materialist or spiritualist, both are agreed that the endless discovery of natural law is the only way to cooperate with it. This alone is organic morality; this alone is progress."

THE MYTH ABOUT BACON AND THE INDUCTIVE METHOD

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THE popular belief that Francis Bacon was the founder of modern science is so flagrantly in contradiction with all the facts of the history of science and so patently belied by the contents of Bacon's "Sylva Sylvarum" or the second book of his "Novum Organum" that it is most instructive to inquire how such an absurd belief ever gained currency among educated people. Unfortunately, however, the history of science previous to the seventeenth century is practically a closed book to those without both a classical and a scientific training. Even professional historians like Professor Robinson in his "Mind in the Making" seem to confirm the conventional fable that there was no science before the seventeenth century. Some indications, therefore, of the actual situation must be set down at the beginning.

(1) No one can well dispute the fact that the great body of modern science rests on foundations already laid before the appearance of the "Novum Organum" in 1620. One needs only to mention the work of men like Copernicus, Kepler, Galileo, Stevinus and Gilbert in physics, or of Vesalius and Harvey in biology—omitting, for simplicity of argument, the great mathematicians from Archimedes to Tartaglio and Cardanus. As all these men had long lines of predecessors as well as fellow-workers, Bacon's repeated claim that there was altogether no well-established science based on experience before he came on the scene would in any other man be characterized as the claim of a crank or charlatan. Ignorance on Bacon's part is too generous an excuse. For he certainly must have known something of the epoch-making scientific work of Harvey, whom he knew personally. Does this not make it appear that Bacon's exaggerated claims to originality as to scientific method was the courtier's desire to gain prestige in the eyes of King James? Certainly his treatment of Gilbert's unpublished writings which were entrusted to him did not show any disinterested desire for the spread of truth.

(2) But whatever we may think of the fact and the motives for Bacon's ignoring the scientific work of his own and previous time, there is the still more significant fact that he positively opposed the great constructive scientific achievements of his day—the achievements on which subsequent scientific progress has in fact been based.

(a) He opposed, for instance, the Copernican astronomy which had received notable confirmation in his day through the scientific work of Kepler and Galileo. This fact is so glaring that many of Bacon's admirers have resorted to strange arguments to minimize it. They have attempted to do so either by softening the statement of the fact or by trying to find some justification for Bacon's position. Neither of these arguments, however, is in the least tenable.

Despite the beclouding efforts of Whewell and others, Bacon's opposition to the Copernican astronomy was emphatically explicit. In his "De Augmen. Scient.,"[1] he speaks of "the extravagant idea of diurnal motion of the earth, an opinion which we can demonstrate to be

[1] Book III, Ch. 4.

most false." This he repeats in the "Novum Organum."[2]

Those who try to save the prestige of Bacon by claiming that in his day the evidence for the Copernican astronomy was inadequate, imply that Bacon's sense of evidence was superior to that of Kepler, Galileo and Gilbert. But this can not for a moment be tolerated by any one familiar with the mathematical work of Kepler, with Galileo's demonstration of the phases of Venus and especially with the very flimsy character of the evidence which Bacon himself adduced for the older view. His boasted proof consisted of nothing else but the naïve repetition of the Aristotelian doctrine that "the eternal motion of revolution appears peculiar to the heavenly bodies, rest to this globe."[3]

(b) Bacon also opposed the growing and fruitful method of explaining physical phenomena as far as possible in terms of mechanics. This method, begun by the ancient Greeks and developed by the Italians in the latter part of the sixteenth century, did not appeal to Bacon, who believed in *species spiritualis* as the explanation of sound and that the "human understanding is perverted by observing the power of mechanical arts."[4] Despite a few grudgingly approving words, Gilbert's genuinely experimental philosophy is rejected in principle. His experiments with magnets[5] are called a waste of time, and his fundamental discoveries in electricity and magnetism which have proved basic are characterized as fables.[6]

(3) Not only did Bacon ignore or oppose what was sound in the science of his day, but he himself, despite all his grandiloquent claims, failed to make a single important contribution to science.

[2] Bk. I., Ch. 46; *cf.* Glob. Int., Ch. 6.
[3] "Novum Organum," II, 35; *cf.* II, 36.
[4] *Ibid.,* I, 66.
[5] *Ibid.,* I, 70.
[6] *Ibid.,* II, 48.

The only two claims in this respect that I have ever seen are that Bacon anticipated Newton's discovery of gravitation and that he discovered heat to be a form of motion. Neither of these claims is true.

The first claim is made by Voltaire in the famous essay which did more than anything else to establish Bacon's great European reputation. But the claim that Bacon anticipated Newton's law of gravitation is absurd on the face of it, since the Newtonian theory is based on the Copernican astronomy, which Bacon rejected. Moreover, Voltaire, like other admirers of Bacon, does not seem to have read Bacon with care or noticed his distinct assertion that bodies lose weight below the surface of the earth.[7] Newton could certainly not have been influenced by such nonsense. Bacon's knowledge that the speed of falling bodies increases as they approach the earth —which Voltaire confuses with the law of gravitation—was an old commonplace in no way discovered by Bacon, whose views went no deeper than the observation that some bodies are heavy, some light, and some neither.[8]

The second claim, that Bacon anticipated the modern doctrine of heat as a form of motion, is likewise untenable. For Bacon rejected the atomic theory ("Novum Organum," II, 8), and his method of induction led him to infer that the motion which produces heat "should take place not in the very minutest particles but rather in those of some tolerable dimensions."[9]

How far Bacon himself was from making any fruitful contributions to science is amply illustrated by the observations and conclusions on almost every page of his "Sylva Sylvanum" and other pretended scientific works. A few examples from the more widely read "Novum Organum" may be cited: Refusing to grant

[7] *Ibid.,* I, 33.
[8] Top. Part Sc. Ob. 3.
[9] "Novum Organum," II, 20.

that fire can ever separate the elements of a compound, he recommends the study of the spirit in every body, "whether that spirit is copious and exuberant, or meager and scarce, fine or coarse, aeriform or igniform, etc."[10] Or consider the queer jumble of unrelated phenomena in his tables of instances on which an induction as to heat is to be based, containing the following gems: Confined air is particularly warm in winter, and "the irritation of surrounding cold increases heat as may be seen in fires during a sharp frost." All shaggy substances are warm, and so are spirits of wine. Boiling water surpasses in heat some flames, etc. I am not unaware that with due diligence somewhat similar absurdities may be culled from the pages of Gilbert, Kepler, Galileo, Boyle and even later writers in the Transactions of the Royal Society. But these men have positive achievement in science to their credit. Bacon has none. Nor could he very well have made any scientific discoveries so long as he believed in explaining things by "spirits" and relying on "axioms" whereby "gold or any metal or stone is generated from the original menstruum."[11]

(4) Others have urged that while Bacon did not himself make any direct contribution to science, he founded the true method of science, the method of induction. There is, however, not a single authenticated record of any one ever making any important discovery in science by following Bacon's method and its mechanical tables and twenty-seven prerogative instances. It would, indeed, be most amazing if the man who ignored or rejected what was soundest in the science of his day, and put down as fact or conclusion so many absurdities as Bacon did, should become the originator or true expounder of scientific method.

It is true that some scientists, *e.g.*, Boyle and other founders of the Royal Society, paid great tribute to Bacon. But none of their really scientific contributions was determined by the Baconian method. It was rather the methods which Bacon rejected, the methods of Kepler, Galileo and Gilbert, that they followed in their successful efforts. Also, the idea of a society for the promotion of natural and experimental knowledge was developed by the Italians (*e.g.*, the Lincean Society, of which Galileo was a member) long before Bacon.

We need not ignore the fact that in the first book of the "Novum Organum" and more especially in his doctrine of the idols, Bacon has given us a most vivid, stirring and still applicable account of the perennial difficulties in the scientific study of nature. But his unusually eloquent appeal for the study of facts as opposed to idle speculation was neither new nor in fact very effective in the actual development of science. In the century before Bacon the Spaniard Vives had made the same criticisms, the same exhortations and almost the same grandiose plans. Indeed, we find the same appeal for the direct study of nature continually urged as far back as the twelfth century by the scholastic Adelard of Bath. But it is all rather futile. Science flourishes not on good intentions produced by pious exhortations, but on the suggestion of definite directions of inquiry and definite workable methods, and these Bacon entirely failed to produce.

Bacon's failure is most instructive because it shows the illusory character of the idea of induction which he and Mill after him made popular. According to this view the scientist begins without any regard for previous thought. Resolved not to anticipate nature, he lets the facts record their own tale. All this is purely Utopian. The facts of nature do not stream in on us with all their relevant characteristics duly marked. The number of possible circumstances that can be noted about any object is indefinitely

[10] *Ibid.*, II, 7.
[11] *Ibid.*, II, 5.

large. Scientific progress depends upon considering only the circumstances that turn out to be relevant to the point of our inquiry. But what we consider relevant, *e.g.*, in the inquiry as to the cause of cancer, depends upon previous knowledge. Hence scientific discoveries are not made by those who begin with an unbiased mind in the form of a *tabula rasa*, but by those who have derived fruitful ideas from the study of previous science. In the absence of carefully considered methods of observation that depend upon previous knowledge and critical reflection, the observation of nature herself is sterile. Those who think they can start any natural inquiry without "anticipating nature" or making any assumptions at all are just complacently ignorant. In any case, any one who begins, in the Baconian fashion, to observe nature *de novo* is bound to find many "facts" which are not so. Thus Bacon himself observes that cold diminishes after passing a certain altitude,[12] that air is transformed into water,[13] that clear nights are cooler than cloudy ones,[14] that water in wells is warmer in winter than in summer,[15] and that the moon draws forth heat, induces putrefaction, increases moisture and excites the motions of spirits.[16] Of course many of the absurd observations that crowd the pages of Bacon were made for him by some of his assistants, like the Reverend Rawley, or taken from popular manuals of his day. But they are in any case typical of what untrained observers can and do record. No reader of Bacon can question his genius or the fertility of his mind; but a comparison of his ideas on science with the works of previous scientists upon whom he heaped rhetorical scorn shows the utter irrelevance of Bacon's ideas to the actual progress of science. Thus his classification of the types of motion display great ingenuity. But all such concepts as the "motion of liberty," in which bodies "strive with all their power to rebound and resume their former density," lack the direct relevance which we find in the ideas of the sixteenth-century Italian predecessors of Galileo, like Benedetti. Compare similarly Bacon's vague statements about colors as "solitary" instances or white color as a "migratory" instance with the observations of Kepler's "Dioptrics" or even with the observations on the rainbow in Vitello's Optics published in 1270. The utter futility of the untrained amateur in science is borne in on us when we compare Bacon's ideas on the motion of the pulse, or his explanation of sex organs[17] with the contemporary work of Harvey.

No wonder that a real scientist like Harvey was moved to say that Bacon wrote science like a lord chancellor.

How, then, in the light of the foregoing readily verifiable facts, are we to explain the tremendous extent and persistence of the tradition that looks to Bacon as the founder of modern science?

The first point to note is that Bacon is still eminently readable, while the scientific works of Kepler, Galileo, Gilbert and Harvey, not to mention their predecessors, are inaccessible to the general reader. The change from Latin to the vernacular as the language of the learned, together with the rapid growth of new technical methods since the eighteenth century, has made it difficult for scientists themselves to read the works of their predecessors of the sixteenth or previous centuries. But Bacon can be read by everybody. His pithy sayings are sententious and quotable like Cicero's. The general reader is carried away by the splendid rhetoric with which Bacon denounces as useless all previous work in science; and his errors

[12] *Ibid.*, II, 27.
[13] "Sylva Sylvanum," 27.
[14] *Ibid.*, 326.
[15] *Ibid.*, 885.
[16] *Ibid.*, 889.

[17] "Novum Organum," I, 27.

of fact or irrelevance of ideas are either not recognized as such or else covered by the very broad but unhistorical reflection that they were good enough for Bacon's times.

The main source, however, of the Baconian myth is the great romantic appeal which inheres in the fundamental idea of organizing science on a new basis calling for no special aptitude or technical training. Technical science involves an arduous routine which can not be popular with the uninitiated. The multitude (including scientists away from their special domain) will always delight in any plan for a new deal in science—"a discovery which will lead to the discovery of everything else,"[18] or "a synopsis of all the natures that exist in the universe."[19] That which makes utopias spring up perennially is found in Bacon's idea that if his system could be established "the invention of all causes and sciences would be the labor of but a few years."[20] Especially in an age that believes in democracy and mechanical progress it is pleasant to be told that science exists for material enrichment and that everything can be achieved by rules leaving little to superior wits.[21] It requires painful efforts to disabuse ourselves of such pleasant illusion.

[18] *Ibid.*, I, 129.
[19] *Ibid.*, II, 21.
[20] *Ibid.*, I, 112.
[21] *Ibid.*, I, 111 and I, 122.

GENIUS AND HEALTH

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All mental activity is the associate of physical activity. It is dependent primarily on the working of nervous mechanisms, but these do not function properly without adequate support from the other organs. It is possible for brilliant exhibitions of mental activity to take place in comparatively feeble or badly diseased bodies, as witness the writing of the "Essay on the Human Understanding" by the consumptive Locke, or the composition of his later quartettes by the dropsical Beethoven, but these are of the nature of exceptions. The production of the former was interminably drawn out and the compositions of Beethoven's last years, though rich in quality, were scant in quantity.

Emerson declared that "genius consists in health, in plenipotence of that top of condition which allows of not only exercise but frolic of fancy." Only the healthy frolic either bodily or mentally.

Bernard Shaw, in his "Saint Joan," defines a genius as "a person who, seeing deeper than other people, has a different set of ethical valuations from theirs and has energy enough to give effect to this extra vision and its valuations in whatever manner best suits his or her specific talents." There needs be specific talents, but there must be energy behind these, and of a very real, bread and butter origin. Certainly Joan was an illustrious example of this definition, as she was of the dictum of Emerson.

"History is philosophy teaching by examples" and perhaps even more truthfully and definitely biography is hygiene teaching by examples, for, aside from the peculiar traits of nervous structure inherited or shaped to some degree by experience, the accomplishment of the great man, whether in quantity or quality, depends on his general physical development and the care which he takes of his bodily machine from day to day.

How the Great Man looked

The great man has usually looked the part. Lowell said of Emerson that there "was a majesty about him beyond all the men I have ever known." Washington impressed those about him as being no ordinary man, and Dr. James Thatcher said "the strength and proportion of his joints and muscles appeared to be commensurate with the preeminent powers of his mind." Goethe was likened in his youth to an Apollo, and the physician Hufeland declared that never had he "met with a man in whom bodily and mental organization were so perfect." Tennyson was "one of the finest looking men in the world." Wordsworth was, according to the artist Hayden, "of very fine heroic proportions." Southey looked an ideal poet, Byron was as beautiful as his verse and was likened to "the god of the Vatican, the Apollo Belvidere." Leonardo da Vinci had a figure of beautiful proportions and a noble and engaging presence. Walter Scott was eminently handsome, "much above the usual standard" and "cast in the mould of young Hercules," with a "fresh and brilliant complexion and a countenance of great dignity."

Physique

The great man has not always been of large bulk or of tall stature. Dr. Samuel Johnson was a Polyphemus for size and strength, but De Quincey was, in the language of Carlyle, "one of the smallest

man figures I ever saw . . . you would have taken him for the beautifullest little child.'' Dumas was six feet tall and well proportioned. Charles Lamb was of diminutive stature and with a ''frame so fragile that it seemed as if a breath would overthrow it.'' The composer and violinist Spohr was of ''Herculean proportions,'' while Weber was ''small, meagre, almost insignificant.'' Thomas Jefferson was six feet, two inches tall, and slender; Franklin was five feet and rotund. The rugged Carlyle was five feet eleven, the deformed and sickly Pope was but four feet six.

Great men have usually been of medium stature, the best height for concentration of bodily power. Beethoven was five feet five, with broad shoulders and firmly built. Siegfried said that it seemed as if ''in that limited space was concentrated the pluck of twenty battalions.'' Brahms was ''rather short,'' ''square and solidly built,'' ''the very impersonation of energy.'' Balzac was five feet high, with, otherwise, ''a colossal body,'' ''his whole being breathed intense vitality'' and ''he both charmed and fascinated the beholder.'' Napoleon was five feet six, slender in earlier years and not very prepossessing, but at forty he is described by Captain Maitland as a ''remarkably strong and well-built man.'' Chalmers was of ''middle height, thick set and brawny but not corpulent,'' with an ''erect, royal air.'' Macaulay was short, sturdy and ''marvelously upright.'' Victor Hugo was erect, strongly built, with a complexion like that ''of a ripe winter apple, fair and rosy as a child's and but little wrinkled.''

Energy and Endurance

Michelangelo was neither tall nor short, fat nor thin, but very muscular and so well preserved that, at eighty-six, he is said to have sat drawing for three consecutive hours, until cramps in his limbs reminded him of his advanced years. Rubens was fond of horseback riding, did not use a mahl stick to steady his hand until he was fifty-seven, and though he lived to be sixty-three, none of his works shows trace of enfeebled powers. Titian was still wielding the brush with almost his earlier skill when he was stricken by the plague at about one hundred. His end ''came as a surprise to his friends,'' says Vasari, ''since he lived a life so strong and resisting that it seemed able to withstand all the assaults of time.''

Napoleon ''could work for eighteen hours at a stretch at one subject or many.'' No eight-hour day for him. ''Never,'' says Roederer, ''have I seen his mind weary; never have I seen his mind without spring; not in the strain of body, wrath or the most violent exercise.'' One of his ministers complained that ''it would require a constitution of iron to go through with what we do. After a day's ride in a carriage we no sooner alight than we mount on horseback and sometimes remain in our saddles for ten or twelve hours successively.'' In his fortieth year Napoleon rode ninety miles without stirrups in five hours and a half. His surgeon Percy said that he was ''made of iron, soul and body, always on horseback, galloping about in all weathers, bivouacking, working like ten men, never ill, never tired.'' Even his enemies declared that Napoleon had a capacity for work equal to that of four other men.

Such powerfully built bodies were storehouses of energy so abundant that it not only displayed itself in work but slopped over into muscular play. Sir Walter Scott was as hearty and hardy as any of the heroes of his novels. As Carlyle said, he ''was intrinsically very much the old fighting borderer of prior centuries. . . . In the saddle with foray-spear, he would have acquitted himself as he did at his desk with his pen. . . .

He could have fought at Redswire, cracking crowns with the fiercest, if that had been the task; could have harried cattle in Tyndale repaying injury with compound interest.'' Despite his lameness he walked twenty or thirty miles with pleasure, and as a woodsman he wielded the axe to more effect than any of his tenants.

Browning looked ''a monument of sturdy health.'' As a boy he was the swiftest runner and best ball player in his school. He was a fine horseman, was a tireless walker and was proud of his strength. Only in the latest months of his eighty-four years did he show failure of his mental powers. Wordsworth at sixty walked twenty to thirty miles a day, was without match as a mountain climber and was ''still the crack skater of Rydal Lake.''

Goethe in his younger years excelled all his companions in active sports. He could skate all day and into the night, and his love of swimming was so great that he braved the water in December. Even when beyond eighty he was still so vigorous as to produce truly remarkable works. Richard Porson, the famous Greek scholar, ''had great bodily strength and often walked from Cambridge to London, a distance of fifty-two miles, to attend his club in the evening.'' Alexander Von Humboldt in some of his expeditions was on foot for fourteen hours a day, and at sixty ''climbed high mountains without show of fatigue.'' ''In my travels,'' he says, ''I kept my health everywhere. I passed through the midst of black vomit and yellow fever untouched.''

Many great generals were remarkably robust. Prince Eugene was possessed of great muscular strength, as was also Marshal Saxe and Turenne. Washington excelled even the hardy hunters and woodsmen in athletic feats. He said of himself, ''I have a constitution hardy enough to encounter and undergo the most severe trials and I flatter myself resolution to face what any man dares.'' He was a strong swimmer, was very fond of dancing and horseback riding. His diary shows that he rode on many occasions as much as sixty miles a day, and Lawrence Washington tells us that he ''usually rode from Rockingham to Princeton,'' a distance of five miles, ''in forty minutes.'' His only demand of a horse was that ''it would go along.'' Any viciousness of the animal mattered not at all to this bold rider. At Mount Vernon his favorite sport was fox hunting, and, three times a week he had, by candle light, his breakfast of ''three small Indian hoe cakes and as many dishes of tea'' and was off with the hounds before sunrise. Thomas Jefferson spent so much time over his studies that he had for his sole exercise while in college a rapid run in the evening to a certain stone a mile distant in the country and return. Like Washington, he was, in his earlier years, fond of dancing. He often walked fourteen miles at a stretch, and to within a few days of his death it was his habit ''no matter what his occupation, or what office he held, to spend the hours between one and three in the afternoon on horseback.'' At the age of seventy he sometimes rode as much as forty miles. Franklin was a great swimmer. On one occasion he swam for four miles in the Thames, ''performing in the way many feats of activity, both upon and under the water.'' He obtained such a reputation as a water dog that he thought seriously of becoming a teacher of swimming. Even at forty he still swam for two hours at a stretch. He astonished his fellow printers by carrying two forms of type to their one, and, in his old age, he was fond of displaying his strength by lifting heavy books. Because of his size and strength Dr. Samuel Johnson was advised by a certain luckless publisher to get a porter's knot and turn porter.

Set upon one night by four footpads, he kept them at bay until the watch came up. He frequently in his younger years walked from Litchfield to Birmingham and back again, a distance of thirty miles, without fatigue, and in his trip to the Hebrides Boswell says that "ninety-five days were never passed by any man in more vigorous exercise." He was a bold swimmer, and though he ordinarily moved like a manacled elephant, he at sixty-eight writes delightedly, "I ran a race this day and beat Baretti." Robert Burns was very robust until alcohol and a morbid outlook on life got the better of him, and his finest songs came to him while following the plough when most of us would be too exhausted to use our brains. Byron was a skilful and strong boxer and he swam the Hellespont in an hour and ten minutes. Poe, before he became a victim of alcohol, was a good runner and jumper, but was especially distinguished as a swimmer. When fifteen he swam in the James River for six miles against a strong tide without apparent fatigue. Dean Swift enjoyed walking and boating, but preferred riding, thinking it good for liver and brain. He punningly wrote to Archbishop King that he "rowed after health like a waterman, and rode after it like a post boy."

Keats was very robust until after twenty-two. He was short but broad-shouldered and was the best fighter in his school. He lived a "clean and strenuous life." After the development of tuberculosis he tramped thirty miles a day in sun or rain in a vain attempt to rid himself of his malady. The poet, Southey, thought nothing of a walk of twenty-five miles when upward of sixty, while Shelley, who was especially fond of boating, though slightly built, "could take an oar and could stick to a seat for any time against any force of current or of wind, not only without complaining, but without being compelled to give in until the set task was accomplished, though it should involve some miles of hard pulling."

Dickens found rest and recreation in walking—"twelve, fifteen, even twenty miles a day were none too much for him," and on one occasion he turned out early and did thirty miles before breakfast. "Swinging his blackthorn stick," says Fields, "his little figure sprang forward over the ground, and it took a practiced pair of legs to keep alongside of his voice." Mark Twain's biographer, Paine, says of him "in no other man have I ever seen such physical endurance."

Though seemingly "an air fed man," Charles Lamb was "as wiry as an Arab" and "could walk all day." Carlyle at eighty-two still walked five miles a day. Tolstoi was an expert swimmer, enjoying the water after sixty-five. At sixty-six he learned to ride a bicycle and to do so without the handle bar. He was an excellent rider, and in his later years he delighted in all manner of manual work. At fifty-eight Tolstoi walked from Moscow to Yasnasa, a distance of one hundred and thirty miles, in three days. He started with three young men, two of whom broke down by the way. Tolstoi reached the end of his journey in a merry mood and declared he had never enjoyed anything so much in his life. John Wesley, while of slight physique, was an expert swimmer and his journal has been called "the most amazing record of human exertion ever penned." Eight thousand miles was his annual record for travel on foot and on horseback for many a long year, and "he spoke oftener and to more people than any man who ever lived." Coleridge, one day of the year in which he wrote the Ancient Mariner, walked forty miles without apparent fatigue. Beethoven, whether it rained or snowed or hailed, or the thermometer stood an inch or two below the freezing point, took his walk in double quick time of five miles or more

into the country. Brahms was a tireless mountain climber, and Wagner was the best "tumbler and somersault-turner of the large Dresden school," was a daring mountain climber and when nearly seventy delighted to astonish his friends by standing on his head. Tchaikowsky read somewhere that, in order to keep in health, a man ought to walk for two hours a day and he followed this rule "with as much conscientiousness and superstition as though some terrible catastrophe would follow should he return five minutes too soon. Leonardo da Vinci excelled all the youth of his city in athletic feats and Turner walked twenty miles or more a day, working as he walked. Emerson at twenty took a pleasure walk of forty miles into Connecticut and at thirty-four mentions in his journal a walk with Hawthorne of twelve miles. Even the delicately made and "washable away" DeQuincey considered fourteen miles as essential to his health, and at seventy he often walked seventeen miles a day.

Sources of Energy

But such display of energy on the part of the great man means that there was a source of energy behind it. There must be an adequate supply of fuel to keep the engine working at such a pitch of perfection. Francis Galton, in his study of men of genius, observed that "most notabilities have been great eaters and excellent digesters on literally the same principle that the furnace which can raise more steam than usual for one of its size must burn more fully and well than common." Tom Tyers remarked of Dr. Johnson that "his bulk seemed to require now and then to be repaired by kitchen physic." Though Johnson declared that he "had never been hungry but once," he always ate "with the fierceness of the famished." "I never knew a man," says Boswell, "who relished good eating more than he did." He was an exacting guest, and when a meal to which he was invited was a disappointment to him he would remark to Boswell, "this was a good dinner enough, to be sure, but was not a dinner to ask a man to." His remarks on feeding are characteristic, honest and wise. "Some people," he said, "have a foolish way of not minding, or pretending not to mind what they eat. For my part, I mind my belly very studiously and carefully; for I look upon it that he who does not mind his belly will hardly mind anything else." The great man is more often but half conscious of what he eats. He is seldom, and the greatest man never, an epicure. He is concerned with larger matters. Napoleon in his earlier years gave very little thought to his eating. He ate hurriedly, his dinner lasting from seven to twelve minutes. He preferred plain dishes and was most fond of chicken, red mullet, roast mutton, beans, lentils and macaroni. He had chocolate or ices served in the midst of his work. As emperor he became more interested in pastries and grew obese from excess of food, but, for his time, he was considered a temperate feeder.

Washington's breakfast consisted of three small corn cakes, sometimes with honey, and of three dishes of tea. At dinner "he ate heartily, but was not particular in his diet, with the exception of fish, of which he was exceedingly fond." He partook sparingly of dessert and when served any dish that was very rich he refused it with the remark, "That is too good for me." His supper consisted of two cups of tea with or without toast. Jefferson ate heartily but mostly of vegetables, of which he raised a great variety. Franklin in his printer days tried vegetarianism partly for the sake of economy, partly for bodily benefit. He, however, returned later to the use of meats, and, as in the case of Napoleon, in his years of prosperity the pleas-

ure of the table often got the better of his bodily activities, and he suffered the consequences in attacks of gout. However, he was quite aware of his fault and so kept his intemperance within such bounds that to the latest years of his long life he was in condition for superior mental work.

Dean Swift "cared not for luxurious feeding. He would enjoy a herring with Vans or bacon and beans with Addison as much as he did turtle with the Premier. When Bolingbroke sent him the menu of a luxurious dinner" he replied, "Pooh! I care nothing for your bill of fare, send me a bill of your company."

Michelangelo is pictured in his last years by Condivi as "healthy above all things, as well by reason of his natural constitution as of the exercise he takes, and habitual continence in food." When intent on some work he "confined his diet to a piece of bread which he ate in the midst of his labors." He was pleased with a present of fifteen margarine cheeses and fourteen pounds of sausage—"the latter very welcome, as was also the cheese." Beethoven paid little attention to his eating but was fond of fish and of macaroni with Parmesan cheese. His breakfast was usually coffee and his supper a plate of soup. Brahms "was extraordinarily modest in his daily life. Thirty-five to forty cents was the most he spent for his dinner and this includes (the cost of) a glass of beer or a half pint of wine." Both he and Beethoven were very fond of coffee. Wagner was frequently changing his diet to test its effect. His biographer says that "what he underwent in vain attempts to diet himself into robust health is almost past belief." He was always a meat eater. "I eat no sweet stuffs," he writes, "only meat, as one may hear, I believe, in my music."

Dumas was interested in affairs of the kitchen and was a master cook. He invented a salad "without vinegar or oil" and other dishes. He "was moderate and select in the matter of his own food" and was "abstemious in drink." In the midst of one of the cholera epidemics his son found him seated alone and devouring several melons. "Don't you trouble," he said in reply to the exclamation of horror, "this is just the right time to eat them—you can get them for nothing."

Scott did most of his literary work before breakfast and this was his chief meal. "No fox hunter," says Lockhart, "ever prepared himself for the field with more plentiful delicacies of a Scotch breakfast, with some solid article, on which he did most hearty execution—a round of beef—a pastry, such as made Gil Blas' eyes water, or, most welcome of all, a cold sheep's head. . . . A huge brown loaf flanked his elbow. . . . But this robust supply would have served him in fact for the day. He never tasted anything more before dinner, and at dinner he ate sparingly." Field said of Dickens that he had rarely seen a man eat and drink less.

Emerson took whatever was set before him and enjoyed it. Pie formed a part of his breakfast and was the first thing attacked. He had two cups of coffee for breakfast and tea for supper. "Rarely he noticed and praised some dish in an amusing manner, but should any mention of ingredients arise he always interrupted with, 'No! No! it is made of violets; it has no common history,' or expressions to that purpose. He tried vegetarianism at the suggestion of Alcott, but finding no benefit in it he returned to the use of meat once a day." Goethe had a cup of chocolate at eleven and his dinner at two. For this meal "his appetite was immense. Even on days when he expressed himself as not being hungry he ate much more than most men. Puddings, sweets and cake were always welcome." Between eight and nine he had a frugal supper of a

little salad and preserves." DeQuincey noted that Charles Lamb was peculiarly temperate in eating, and the same could be said of DeQuincey, for coffee, rice, milk and a square inch or two of mutton were the materials that invariably made up his meals.

The great genius has sometimes become so absorbed in his labor that he has neglected for long periods to take in fuel, and when he did so, he has had to make up for the omission. Balzac during his spells of composing would work for "eighteen to twenty hours daily for weeks, seeing no one, eating sparingly, sipping his coffee, and refreshing his jaded anatomy by taking a bath, in which he would lie for a whole hour plunged in meditation." After such a fast he once appeared suddenly and at a restaurant ordered and practically consumed all the following: "a hundred oysters; twelve chops; a young duck; a pair of roast partridges; a sole; a relish; sweets; fruit (more than a dozen pears being swallowed); choice wines; coffee and liquids."

The great man has been as temperate in drink as in meats. He is too keenly conscious of the depressing effects of alcohol not to avoid its influence. Some few, like Bismarck and Dr. Johnson, could consume enormous quantities without apparent effect, but the latter abandoned his excessive consumption, observing that "wine gives a man nothing. It neither gives him knowledge nor wit; it only animates a man, and enables him to bring out what a dread of company has suppressed. . . . But this may be good or it may be bad." It is "one of the disadvantages of wine that it makes a man mistake words for thought." Schubert and Burns purposely drowned their hypersensitive souls in wine, and suffered the consequences as did Poe, while Thackeray shortened his days with dinners and drinks. Herbert Spencer took opium for sleeplessness and Coleridge and DeQuincey because of bodily pain, and the latter manfully threw off the yoke of bondage after he had reached a dose of eight thousand drops. Even in an age when alcohol was a part of every meal, Wordsworth and Shelley drank only water, and while Keats possibly found inspiration from wine, DeQuincey's "most deadly certainty of failure was the touching of anything in the nature of wine or spirits." Wagner was disgusted with the wine bibbing and beer indulged in by those who celebrated his birthday.

Rest

It is often said of great men that they needed and took but few hours of sleep. It is true that in their desire to accomplish as much work as possible they have spent no more hours in bed than was necessary, but those who found that less than six or eight hours would suffice them were very few. Alexander von Humboldt, Linnaeus, Cuvier, Dumas, Bismarck and the composer Dvorak are all the four-hour sleepers I have come upon in a long list of distinguished men. Napoleon, who is sometimes mentioned in this class, took from six to eight hours and did not hesitate to nap in the daytime and even in the midst of conversation. He could go for long periods without sleep, but he always condemned himself to correspondingly long periods of rest afterward, sleeping on one occasion for thirty-six hours at a stretch.

Goethe was a very sound sleeper, and Descartes, who is said to have done more original work than any man of his century, slept a great deal. Brahms could sleep at will and under any conditions and Dumas, "after writing for some hours at a stretch, would suddenly fling himself on his bed, and in a few seconds be sound asleep; fifteen or twenty minutes later he would wake up again with equal abruptness and return to work—a giant refreshed."

The great man has, because of his concern for fitness for his task, tried to keep himself in superior health, though this was not always possible. A few brilliant geniuses have fallen early victims to the bacterial scourge of the day which fell upon the strong and weak. Raphael was carried off by bubonic plague, Mozart by typhus fever, Keats, Chopin and Weber and others by tuberculosis. A few great men, a very few, through over-sensitiveness to their treatment by the world, lost their genius and their lives by dissipation. Sad examples of these are Burns, Schubert and Poe. Jonathan Swift was early attacked by a disease of the ear which extended to his brain and clouded his later life. He fought it tooth and nail, though without effect. He wrote at fifty-five, "without health and good humor I would rather be a dog."

The Shackles of Sickness

A few great people, robust in early life—Darwin, Carlyle, Spencer, George Eliot and others—suffered from ill health in middle life and were limited in their working hours probably from the disastrous results of eyestrain. Herbert Spencer, at the age of thirteen, in a fit of homesickness, walked from school to his home, covering forty-eight miles the first day, forty-seven miles the second and twenty the third. Though he seemed little the worse for this journey, this, with his later engineering work of eighteen hours a day, may have been sufficient to injure his highly strung nervous system.

Taine, the eminent French scholar, set for himself in youth a daily program of mental toil, with only twenty minutes' play after dinner and an hour of music in the evening. Not an eight hour, but a sixteen hour day. By thirty his mental machinery was working badly, and his program had for years to be reversed, so that he read or wrote for an hour or two and spent the rest of the time in gardening, in twelve-mile walks and the like vegetative occupations. Writing at thirty-four he says: "I am like a violin of which the pegs are too small; having become worn out from being constantly turned, they no longer bite the wood but slip and let the strings become loose, so loose that the sound is spoilt and often altogether absent." Nevertheless, a man who can undertake twelve-mile walks is no weakling and perhaps Dr. Gould was right in attributing his ailments and distress in mental work to eyestrain; he certainly showed some symptoms, but the "intellectual" pace set in his early program was nevertheless a hazardous one.

Lord Bacon spoke of himself as "a man of no great share of health who must therefore lose much time." Spinoza early suffered from disease and was an invalid by forty. John Locke kept his frail body in health until thirty-five, but from that time he suffered from lung disease which "painfully impeded his schemes of work and occasionally induced states of mind altogether at variance with its otherwise robust character." He was twenty years in writing his famous "Essay on the Human Understanding." It was done, he tells us, "by incoherent parcels and after long intervals of neglect." No man was more keenly impressed with the value of health, and his "Thoughts on Education" begins with the words, "Our clay cottage is not to be neglected"—for "he whose body is crazy and feeble will never be able to advance in it."

Immanuel Kant is the most remarkable of the great men of frail physique. "Possibly a more meager, arid, parched anatomy of a man has not appeared on this earth." He was so delicate that it is said that he took cold from handling damp proof-sheets. Yet by the utmost care he kept himself for nearly fourscore years in the nicest of health, "like a gymnastic artist," as he expressed it, "balancing himself upon the slack rope

of life without once swerving to the right or to the left." However, despite the great sway of his influence over the thought of the world, he found himself disturbed in his larger plans by the narrow limits of bodily power within which they must be worked out.

Edwin Booth was limited in his physical endurance and found himself too exhausted after his acting for further exercise, while Lord Lyons, one of Great Britain's most distinguished diplomats, worked most exceptionally to within a month of his death at seventy, with only so much muscular exercise as was necessary to get him about his house and to his carriage.

St. Bernard, St. Francis and Savonarola are said to have injured their health by over-enthusiastic fasting and other ascetic practices, while Martin Luther, after starving himself in the monastery to the point of emaciation, went, after his break with Rome, to the opposite extreme and suffered the consequences of high living. He drank wine, as he put it, "to spite the devil," that is, the devil in the form of monasticism. He meant well, however, for he said, "We ought to do our part, and take care of our bodies; but when we are tempted, abstinence is a hundred times worse than eating and drinking."

Many great men, like Johnson and Dickens and Gibbon and Macaulay and Watt and Turenne, were very delicate children who by special care attained superior health and lived a long life. Another of this group, Descartes, said of himself: "The conservation of health has always been the principal end of my studies."

Physique and Profession

Of the great men already mentioned it will be noted that the artists and musicians and poets are, contrary to the usual notion, quite as robust as the soldiers or statesmen. It was pointed out by Francis Galton that of all groups of the great the clergymen who have attained distinction show the greatest number of physically inferior men. There are good reasons for this in that to within very recent times the spirit of asceticism so swayed the church that the body was too often looked upon with indifference, if not with contempt, by its ministers, the ministry itself was looked upon as fit only for the feeble and was, because of the general atmosphere of asceticism in which it was shrouded, shunned by the more robust. Phillips Brooks said that he felt he was giving up his manhood when he entered upon the work of the ministry. All this is changed and with it the physique of the minister is changing. The delicate child is no longer considered by his parents as predestined a preacher. In a recent installation of a clergyman in a pulpit of direct Puritan descent, a conspicuous part of the charge to the new incumbent referred to the care he should take to preserve his health and strength, since on these the whole success of his work would depend.

Francis Thompson has pointed out that we moderns are scourged quite enough with dyspepsia and other ailments without the use of the whip or the hair shirt. As shining examples of the robust great man in the pulpit, we have, besides Phillips Brooks, who was never sick, Beecher, who knew no fatigue he could not sleep out in a night, Spurgeon, Chalmers and many other giants.

Philosophy has also enrolled in her ranks many men of frail physique, as Kant and Spinoza and Bacon, but it has also had among its followers such robust beings as the hardy, hoplite soldier Socrates, the "healthy and high spirited Mill," and Hobbs, who at seventy was an enthusiastic tennis player and who still wielded his pen at ninety.

The Great Man as Health Teacher

The man ambitious to work out his life task in the most perfect manner has

felt more keenly than the man of lesser inspiration the need for the most sensitive and enduring bodily instrument with which to accomplish his work. Feeling so keenly the handicap of ill health he has had a finer insight into the laws of health. The most eloquent sermons on hygiene are to be found, not in the professional health books of the day but in the writings of such men as Molière, Cervantes, Montaigne, Michelangelo, Walter Scott, John Wesley, Carlyle, Bacon, Smollett, Rabelais, Locke, Voltaire, Johnson, Swift, Berkeley, Beecher, Franklin, DeQuincey, Kingsley, Browning, Francis Thompson and Emerson.

Though these and many more great men have preached the precepts of health, they would have been the last to have given health undue concern or to have desired others to do so. In fact it is one of the secrets of their own health and accomplishment that they made the quality and quantity of their work the test of health. Idleness and introspection are ruinous to health. Health is developed most by the exercise of all one's faculties in absorbing work. One must lose himself to find himself. The real invalid Molière laughs at the man who makes himself miserable with imaginary ills, and Joseph Addison, suffering as he was from asthma, devoted one of his essays to the folly of paying undue attention to health. "I do not mean," he says, "that I think any one to blame for taking due care of their health, on the contrary . . . a man can not be at too much pains to cultivate and preserve it. But this care . . . should never engage us in groundless fears, melancholy apprehensions and imaginary distempers, which are natural to every man who is more anxious to live than how to live."

The composite picture obtained from this study of great men—the picture of *the great man* is that of a being who made the most of his bodily possessions. Usually these were strikingly superior. Seemingly they unfolded apace to fit the aspirations of the spirit within, for it was noted by Plato that it is not the good body that improves the soul so much as the good soul that improves the body. Not only does the great man, the truly great man, care, according to his knowledge, for his own body, but he is so keenly sensitive to any hampering by bodily imperfections or missteps that he has often felt called upon to preach the gospel of health to others, and his sermons have been of the highest value. The exceptions to the picture which we have noted have been the lesser men. Because they were exceptions, they fall outside the composite and if they blur it, they also produce a shadow which intensifies the figure it surrounds.

We can not all satisfy our ambition to be great, but we may at any rate come nearer attaining that end if we look with the respect of the great man upon the physical foundations on which all our work and pleasure depend. The exclamation of the slowly dying John Locke sounds across two centuries like a trumpet call: "While we are alive let us live," for, to repeat the words of Michelangelo, "a man does not come back again after death to patch up things ill done."

THE LIES THAT CHILDREN TELL

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FLASHING brighter and brighter in the firmament of modern science is the rising star of child study. Yet the growing interest manifested in the scientific understanding of child behavior is of rather recent origin. Before the present century, as a matter of fact, scientific child study can hardly be said actually to have existed. True it is, of course, that such eminent formulators of pedagogic theory as Rousseau and Pestalozzi —and a few others—attempted to repose their multifarious educational precepts upon their understanding of child nature. Unfortunately, however, their knowledge of children was circumscribed and scanty. Saturated, moreover, with philosophic theory the traditional methods of research of the old type of child study were based for the most part upon introspection and uncontrolled observation. Whatever permanent results such methods achieved were due in large measure to the pedagogic intuition of a few far-sighted investigators rather than to any keenness or intrepidity of research. Moreover, when the penetrating light of science actually began to illuminate the field of child study, the attempt was usually made to seep over the entire area of child development in as *general* a way as possible. This generalizing attitude was due largely to the influence of the early pioneers in child study for whom there was of course little need for specialization since the field itself was as yet quite untilled.

However, this early attitude, while still existent among a few eminent child psychologists, especially in the Old World, is, nevertheless, gradually disappearing. In our own country to-day child study is indeed a field of specialization. This is the result in part of the rapid development of the field in general and also the constantly increasing number of new problems. Moreover, in view of the growing tendency to see in psychology a study of human *behavior* rather than of the human *mind,* child study is gradually emancipating itself from the impeding tentacles of tradition. As a result it is beginning to study children more and more from the point of view of their daily actions and performances. This fact alone would be sufficient to drive even the most versatile student of children into the arms of specialization, for child behavior in its entirety is so multiple and so kaleidoscopic as to be utterly beyond the thorough mastery of even the most capable and energetic scholar.

This article is an attempt to consider only one aspect of the child's many-sided behavior—the lie. We have chosen this particular phase of child life not only because it is unquestionably one of far-reaching interest but also because so little about it has appeared in American publications—scientific as well as popular. The dearth of first-hand scientific material on child lies is due for the most part to the belated development of this special field of study—the reasons for which have already been set forth. Four important aspects of our problem will characterize the following discussion: (1) the causes of the child lie; (2) the pseudo or apparent lie; (3) the real lie; (4) the treatment and prevention of lies.

II

Scholars vary considerably in their attempts to explain the causes of the child lie. Adopting the attitude of Rousseau there are those who believe that the child as it is born into this world is entirely good, that its "degeneration" is the result of the evil influences of man and his contaminating environment. The adherents of this viewpoint are generally known as *empiricists*. With Rousseau they hold that "the lies of children are the work of their educators." Opposed to the doctrines of the empiricists are those of the *nativists* who stress the belief that whatever the child is, it is by virtue of its inheritance. For the nativists environment plays but a small and inconsequential rôle in the drama of life. The child, it is their contention, is not merely amoral: it is actually antimoral. The lie, as the nativist sees it, is only the beginning of an individual's unbridled egoism. Between these two extreme viewpoints which ascribe the child lie either wholly to the influences of environment or on the other hand solely to those of inheritance is the more moderate and reasonable attitude of *convergence*. The proponents of this manner of thought see in the child lie a very complex aspect of human behavior which can be fully explained neither on grounds of heredity nor on those of environment. The protagonists of convergence believe that the genesis of the child lie is the result of an interweaving of the influences of nature and nurture. Doubtless this third attitude is the most plausible. Scientifically, also, it is the most tenable.

Close analysis will show that the lies of children are multiform; that often they defy exact classification, and that they can not always be patterned according to any definite standards. To say, therefore, categorically—without further evidence than that now available—that such a complex form of human behavior as the child lie is instinctive, or that, in other words, it is an unlearned, inherited type of human activity, is a scientific absurdity. No modern student of child behavior, guided to his conclusions by careful and painstaking research, would subscribe to such a one-sided opinion. As a matter of fact, the question has been raised by some psychologists whether normal children under the age of four actually, if ever, tell a lie. And yet, if the standpoint of the adherents of the convergence idea is correct, then certain qualifying elements of the child's lie must be due to factors of inheritance as well as to those of environment. It is doubtless true that in spite of their indefinable variety child lies usually—though not necessarily always—are colored by certain tints which are ordinarily determined by inheritance.

First and foremost among such qualifying elements is the matter of self-preservation. This causes the child to assume an attitude of defense towards imminent danger or threatened unpleasantness. Frequently, moreover, such an attitude is conditioned by fear. In fact, one of the greatest contributors to falsehood among children is their fear of punishment. Thus, rather than to face punishment for some alleged misdeed, great or small, children will rush to their most natural avenue of escape—the lie.

Then again, the child may be impelled to deviate from truth or reality by its imagination or fancy. This after all, however, is merely a playful relationship between the child's mental status and the outside world of cold facts:

> Idealizing temperaments [says G. Stanley Hall] sometimes prompt children of three or four suddenly to assert that they saw a pig with five ears, apples on a cherry-tree, and other Munchausen wonders, which really means merely that they have had a new mental combination independently of experience.

Whether such flights on the wings of fancy should actually be designated as

lies is highly questionable and will be considered at greater length further on in this discussion.

Rather similar to the child's inborn inclination to imagine reality of things that are unreal is its tendency to mimic and to imitate. Children will thus pretend all sorts of things. To quote G. Stanley Hall once more: "They are animals, doctors, ogres, play school . . . are dead, mimic all they see and hear." Here again it is open to doubt whether the child is actually lying in the real sense of the term.

Another factor to be considered in the lies of children is the child's volitional nature. This, too, is more or less inborn and consequently rather independent of environment. Weakness and dependence of will subjugate the child to swarms of suggestive impressions which not infrequently will cause the child to err in questions of fact. Strength and independence of will on the other hand serve as dynamic weapons in the child's battle against the hordes of temptations leading to falsehood.

All the foregoing aspects of untruth—self-preservation, imagination, mimicry, power of will—are only formal determiners of behavior. They represent only partial components of a lie. A child may be telling a falsehood and yet not be impelled by any single one of these influences of heredity. As a matter of fact, lies in most situations are determined not alone by any single member of this quartet of inborn tendencies but also by a multiplicity of external factors produced by environment. It is the preponderance of these environmental conditions which makes it possible to prescribe methods of treatment for juvenile lies, except, of course, in those cases that are purely pathological.

Perhaps the most convincing argument in favor of environment as a conducive agent to veracity is the fact that lies are much less prevalent among children of the socially better classes than amongst those of the lower social strata. This has been ably demonstrated by a number of European investigators, foremost among them being Dr. William Stern, professor of child psychology at the University of Hamburg. Of course, in a certain number of individual cases it may also be true that the child of the lower classes, besides being placed in a most unfavorable environment, is also endowed with certain innate proclivities tending to foster untruth. Yet, even if such native tendencies were entirely absent, the relative lack of veracity among such children should not be altogether unexpected. In the first place, such youngsters frequently are entirely lacking in proper and able guidance. During the greater part of the day both of the child's parents are usually away from home. The child is thus left to amuse himself, or what may often be even worse, he is thrust into the company of questionable companions. Left to itself the child will naturally give way to unfettered flights of fancy. Frequently it may become entangled in the web of suggestion which will cause it to do things which in the end are sure to bring about punishment. Playing with its pals the child will often be duped and deliberately misled to perpetrate deeds the detection of which will inevitably result in punishment. And then when the young miscreant is discovered, the punishment he receives usually serves as a vent to the coarsest kind of parental anger rather than as a remedial means of curing a juvenile defect. What could be more natural, then, than that the child should renounce truth? The very injustice of its punishment becomes the birth pang of future falsehood. There is little doubt that if such children were given proper guidance under propitious home conditions their propensity to lie would decrease very largely and they would grow up at least as average truthful individuals.

It must, of course, not be assumed that children of the so-called cultured classes do not lie. As a matter of fact conditions in such homes are often of the very kind that incite children to falsehood. Here, too, the child is not infrequently without judicious parental training. The number of families in which both parents go to business seems to be increasing. Needless to point out that servants—even the well intentioned—are not always the best child trainers—especially in the matter of veracity. Moreover, in our concentrated and complex city civilization the number of families living beyond their income in order "to keep up" in social position and dignity with other families is also on the increase. Children in such families are quick to be inoculated with the germ of duplicity. As a matter of fact, their parents, in their efforts to throw dust in the neighbors' eyes and thus conceal the family's true economic status, have in all likelihood cautioned their offspring to practice a similar form of deceit. Furthermore, there are also of course the multifarious "white lies" of convention with which children are thrown into constant contact. Even some of the most respectable families, guided by a very lofty sense of ethics, see no harm in such trifling falsehoods and make little effort to protect their children from their influence. While such petty artifices may deceive no one and may be quite harmless as far as adults are concerned, for children they are positively dangerous. More than any other factor, perhaps, they call the child's attention in a very direct way to the fact that there is such a thing as *conscious divergence from truth,* and that this, moreover, is indulged in by their elders with apparent impunity. Not only may this stimulate the child itself to lie; but frequently also it shatters beyond repair the child's unquestioning confidence and trust in its elders. And when this is gone, child training—in *all* respects—becomes a most difficult and hazardous undertaking.

Besides these few environmental causes of child lies there are countless others. An exhaustive discussion of all within the realms of this brief paper is manifestly impossible. One such influence, however, is so common that even a most cursory discussion such as this must make mention of it. Prevalent in most families throughout the world is the tendency on the part of parents to ask altogether too many questions of their children. The average parent delights in playing the rôle of some Grand Inquisitor and expects his children to answer his many questions with unfaltering ease and unimpeachable accuracy. Now, the question, unless employed by one well versed in the art of interrogation, is one of the most puissant contributory causes of the child lie. It has in fact been shown that answers based upon questions tend to be at least five times more erroneous than statements made spontaneously.

> Continual cross-questioning [says Dr. Stern] not only leads to unconscious splits of memory, but, in the end, to conscious untruths. The questioner seems determined to have an answer, so the child obliges him by saying something that will put an end to the uncomfortable examination.

The danger in subjecting the child to unnecessary questions is resident chiefly in the power of suggestion which may generate in the child's mind false ideas which otherwise might be entirely absent. To be eschewed especially is the leading question—that type of interrogation which seems to contain the answer within itself, but which to the unthinking child often becomes a treacherous snare.

> For the question "Was the cloth not red?" the answer "Yes" is always readier than "No." The naïve human being is much inclined to affirm any idea presented to him, *i.e.,* to accord it with objective existence [Stern].

If such questions tend to mislead intelligent adults, what must their effect be upon immature and uneducated children?

Epitomizing what has been set forth so far, we note that the child lie is a form of human behavior of incalculable intricacy; that its origin and causes are traceable sometimes to the influences of heredity, but more often to environment; most frequently of all, however, to the combined action of the intermingled and wide-reaching forces of nature and nurture.

III

The difference between truth and its opposites is ordinarily plain to perceive. Yet its very simplicity often tends to becloud the distinction. From our previous exposition, however, it should be more or less clear that in a scientific sense it is not always satisfactory to label every digression from fact as a lie. We have intimated that in certain instances, especially in those where the child is deviating from truth by virtue of its inherent imagination or its tendency to mimic and to imitate, it is psychologically doubtful whether the child is actually lying. Such cases of apparent prevarication the student of child behavior prefers to call *pseudo-lies* in contradistinction to *real lies,* the salient difference between the two being that in the case of the former the deceiver is not moved by any distinct purpose to deceive. A real lie is always a consciously false statement that aims to achieve certain results by the deception of others. It is the lack of this purposive element which characterizes the pseudo-lie and differentiates an imaginative invention from a real lie. Most prominent among the innumerable types of pseudo-lies are those spurious untruths due to imagination, fancy, play, mimicry, imitation, tricks, etc. As a matter of fact, of the normal child's lies more than half would be of this group.

Bearing these facts in mind let us now throw the light of our discussion upon a few concrete examples of some of the many types of pseudo-lies. A veritable treasure-house of such is afforded us in the autobiographies of eminent men. The life stories of authors, painters, sculptors are especially replete with such types of childish invention.

Gottfried Keller, the Swiss raconteur, reports in his autobiography that when he was still quite a youngster he once spread the news of his discovery of a chest containing incalculable masses of gold and silver. So real and vivid were the details of his invention that many of his companions—and even some of his elders who should have known better—began to look for the alleged place of discovery. When one of his youthful companions ventured to play the rôle of a doubting Thomas, young Keller sought to reinforce the quivering threads of his invention by showing his sceptical questioner some gold and silver coins—which, however, he had received as a birthday gift.

On another occasion Keller startled his comrades by maintaining that he had given gold and silver necklaces and bejeweled bracelets to a wealthy lady from the city who happened to be passing the warm days of summer in the coolness of Keller's native village.

Goethe, in his "Dichtung und Wahrheit," tells us how he, as a boy, was wont deliberately to mislead his companions by passing off self-imagined tales as his own experiences.

> . . . it made them marvel to think that such wondrous things should have befallen me, their comrade. These inventions, of whose truth my comrades made passionate attempts to convince themselves, were held in great esteem. Alone, each one for himself, used to seek out the alleged place of my experiences. . . .

The cases of Keller and Goethe are representative pseudo-lies caused by a powerful imagination. Both lads, no doubt, were stimulated by the vividness

of the mental pictures which they had absorbed from their readings.

The late Professor Meumann has reported several interesting cases of pseudo-prevarication. The following stands out especially:

> I knew a little girl of four years of age which, absolutely unabashed, claimed as her own many of the experiences of her six-year-old brother—even though the home training of the child was admirable.

This case has much in common with that of young Goethe. Obviously, however, it is not due to the child's reading, since the child was much too young to be thus influenced. It is rather a case in which the child had heard of certain experiences of its brother and then, having in all likelihood been powerfully thrilled by these, it had permitted its memory to be side-tracked by its stronger and better developed imagination.

The following is an interesting case reported by the wife of Professor Stern:

> We were speaking of H.'s little sewing basket when little E. playfully stated: "I got such a sewing basket from my Granny." E.'s brother and sister were astounded and so I suggested to them: "E. is only joking." But E. insisted: "No, no, no! Granny really and truly gave me one." Whereupon her brother curtly accused her: "Why, E. that's a fib!" . . . Finally I asked E. to show me the basket and now she became sulky and was on the verge of tears; and yet it was still some time before she would reply with a "No" to our questions whether or not she really had received such a basket.

Doubtless there are many parents who, without further analysis, would consider this instance of prevarication as something more than a mere pseudo-lie. However, while it is of course most difficult to evaluate the situation on the basis of cold words entirely divorced from underlying conditions, the actual motive for the child's untruth seems most innocent. There is here an entire lack of any purpose to achieve something by means of deception. This is again a situation in which the child is merely playing with reality.

Many apparent lies are due to the fact that the child's speech is still in a more or less half-developed state. This is especially true, of course, of younger children, who, in order to express their affective attitude, frequently employ terms of speech which the adult uses solely to affirm or deny facts. The little two-and-a-half-year-old boy who had been ill and who had formed the habit of crying "Ouch!" whenever anybody touched him did not really mean to give the impression that he was in pain, but merely wished to convey the information that he wanted to be left in peace. The word "no," which to the adult represents an unequivocal denial, is often employed by the child in an endeavor to get rid of something unpleasant. Thus, the three-year-old youngster who had struck his little sister so that she cried, when later reminded of the fact that he had hurt her, vehemently cried out: "No, no, no!" This negation, however, is not to be taken as a lie. Rather does it represent the lad's wish to hear no more about his misdeed. It is merely the child's crude way of saying: "I'm sorry; please don't remind me about it any more."

It has already been suggested that a great source of misstatement on the part of children is due to the questions to which they are frequently subjected. Since at the outset the child's answers are not a conscious attempt at deception such childish misstatements should be classified as pseudo rather than as real lies. The danger of these unconscious misstatements inheres not in themselves but in the fact that they may eventually lead to conscious and deliberate falsehood. The moral to be observed is that one should ask no more questions of children than are absolutely necessary and that one should formulate these as carefully as possible. The following incident

reported in a number of European dailies more than a score of years ago illustrates in very definite manner the important rôle assumed by the question:

One day a little boy disappeared mysteriously. One of his comrades reported to the boy's distraught parents that the 13-year-old X had told him that he had been swimming with the missing boy and that he (X) had pushed the lad into the water when the latter wasn't expecting it and that consequently he had drowned. [Note: This statement of X may actually have been true in part or it may have been entirely an imaginative invention.] Cross-questioned by the missing lad's father—who naturally was under great emotional strain—X became more or less intimidated and admitted everything he had previously reported. Finally the case was dragged into the courts and here again X, when questioned with regard to specific details of the alleged incident, pointed out everything requested with sharp precision. When, however, X was approached with kindness so that his confidence was stimulated, he contradicted almost all his previous testimony. In a word, then, X could no longer differentiate between actual fact and that which had been suggested to his receptive juvenile mind in the form of dubious interrogation. After several days the lost boy returned and thus what might otherwise have ended in tragedy terminated more fortunately.

This case is typical and it is only one in many. Both the child and the questioner were acting in good faith. The questioner's interrogations, however, instead of arriving at truth only succeeded in befuddling the child's mind and in producing a most confused conglomeration of responses. It is in view of these facts that several of the larger cities in Germany are to-day making serious attempts to require the presence of a professional psychologist in those cases where the testimony of children is to play more than an ordinary part.

IV

Definitions of "real" lies are as numerous as they are varied. Disregarding entirely the ethical aspect of a lie and interpreting our term merely on the basis of our previous discussion we shall define a real lie as being a *conscious* and *deliberate* attempt at deception for the *purpose* of achieving certain results. The fact that a real lie is a conscious misstatement as well as a deliberate one differentiates it from an accidental lapse of memory; the fact that there is a distinct purpose in view divorces it from the realm of imagination. This threefold nature of a real lie presupposes a fairly advanced state of psychic development. There must be sufficient judgment to discriminate between fact and fable and to dissimulate a lie so well as to make it appear as truth. Then, also, the power of will must be sufficiently strong to arrange and classify the various actions necessary for the deception and for their carrying out. Those psychologists, therefore, who questioned whether a child below the age of four ever told a real lie were not so pedantic as might ordinarily be assumed. The majority of real lies owe their origin to pathological rather than to any other causes. Bearing in mind that what seems to be a lie is often not a lie at all, one should not be surprised to find upon close analysis that the real lie among normal children is not such a common phenomenon as is popularly believed.

While the incidental elements may vary considerably, the majority of real lies is usually ascribable to fear. This cause and effect relationship between punishment and a lie is clearly resident in the following case:

A three-year-old youngster once did some trivial thing which he should not have done. When his father asked him what he had done the boy said: "I don't know." But when the parent insisted on the correct answer, the lad, instead of giving it, said: "Don't hit me! Don't hit me!"

The most reprehensible form of a real lie is that which affects not only the child himself but which drags into its net absolutely innocent people. Such cases usually fringe on the borderland

of the pathological and fortunately are not so common among normal children. The following is a typical example:

While the mother of a six-year-old youngster was out visiting, her boy in playing about the drawing room smashed the glass door of a valuable bookcase. When the mother returned, the lad rushed out to meet her and related a long and involved story of how the maid in cleaning the drawing room had poked the handle of her broom through the glass door of the bookcase. The youngster even went so far as to illustrate the precise way in which the maid had committed the alleged misdeed. Fortunately, however, the boy's mother happened to recall that the maid had given the drawing room a rather thorough cleaning that very morning. And yet it was not until after much persuasion *and the promise of no punishment* that the boy, very hesitant and much ashamed, finally admitted his lie.

Somewhat similar to the foregoing incident but not quite so involved is the following, reported by Paulo Lombroso in 1905:

A three-year-old girl, while visiting a friend of her mother, broke her little doll which she had taken along. The woman whom she was visiting tried to talk the little child out of its fear that it would be punished at home for its broken doll. Arriving at home, the child told the story that the woman had broken the doll—convinced no doubt that the woman, in order to safeguard it from punishment, would also assume the guilt.

Not all lies, however, trace their genesis to the fear of punishment. A small minority results from other causes. Thus, a child will sometimes attempt deception in order to avoid something it dislikes exceedingly, or on the other hand, to gain something it likes very much. To avoid doing its homework a child may say that none was assigned or that the work has already been done. These same statements might also be offered by the child that is anxious to go out and join its fellows in play. To get out of eating something it does not particularly relish a child will feign illness. The writer is acquainted with a certain youngster possessing a pronounced aversion for rice. Whenever this farinaceous hobgoblin is served, this particular lad will eat a mouthful or two and then suddenly drop his fork and writhe in terrible agony. Yet whenever rice is served in the form of pudding, strange to relate, the horrible "pains" never appear.

A fairly large number of real lies are prompted by some form of selfishness.

Every game [says G. Stanley Hall], especially every exciting one, has its own temptation to cheat; and long records of miscounts in tallies, moving balls in croquet, crying out "no play" or "no fair" at critical moments to divert impending defeat, false claims made to umpires, and scores of others show how unscrupulous the all-constraining passion to excel often renders even young children.

It is of course hardly necessary to comment that this particular form of fabrication is not at all monopolized by children; and that their elders are sometimes rather prone to participate therein.

Somewhat akin to selfishness as a cause of the real lie are the child's love of showing off and its desire to appear big and important. Commonly known as bluff these manifestations of self-glorification are at times quite innocent. Frequently, as in the cases cited of Goethe and Gottfried Keller, they are due to an exuberant childish imagination. Unless the child aims to achieve a definite purpose by its deception it is not —in the light of our definition—actually lying.

An eleven-year-old girl heard its school companions speaking a great deal about tours, costly equipment, etc. Since its own parents were poor and it could never hope for such things, and since it did not wish to appear inferior to its companions, the child fabricated a series of lies—so carefully, however—that no one was able to detect the untruth. The kernel of this untruth centered about a prominent man with whom the father of the child was acquainted in a business way. According to the stories of the child this gentleman now became a regular visitor of the child's home and thus every day it had some new incident

to relate, how he had been a guest at dinner, how her parents had given a large party in his honor, how he had drunk a toast to the health of her parents, etc. [Lombroso].

Unquestionably this form of fabrication approaches very closely to the pseudo-type of imaginative invention. The fact, however, that this child had a definite purpose in view, *viz.*, the simulation of parental wealth and social position, makes its lie more real than apparent.

The following form of child behavior is perhaps even a more definitive case of a real lie caused by the child's love of appearing important and better than its fellows:

A teacher of drawing had asked her young pupils whether one of them would not be able to bring in some flowers to be used as a model. A six-year-old youngster, remembering that his mother had received some flowers a short time ago, proudly volunteered that he would bring them to class. At home the child was informed that the desired flowers had been thrown out. In order not to appear foolish before its classmates the boy stole a pot of flowers from one of the neighbors and brought these to the teacher, attempting to pass them off as his mother's.

V

If the child lie were exclusively a matter of inheritance, if it were merely a question of instinct, or if, as is so commonly assumed, the juvenile lie were a necessary evil to be passed through like the measles or chicken-pox, then assuredly there would be little to gain in formulating methods of prevention. Since, however, the lies of children are the result not only of inheritance but of acquisition and environment as well, it may perhaps be prudent to pause for a moment to consider the short prescription which science has to offer in order to immunize the child against the lie.

Like most other diseases the lie is most susceptible to treatment before it has been given a chance to develop. Prevention, in other words, is better than cure. It is here that the popular fallacy which assumes that the child lie is a "necessary evil" imposes a burdensome handicap upon the unsuspecting parent, for, given even a tiny foothold, lies will quickly develop into deeply rooted habits, most difficult to eradicate. An occasional lapse into the realm of falsehood is of course not in itself a cause for alarm; neither, however, is it proof of the contention that lies in childhood are normal and usual. As a matter of fact psychological analysis has shown that potentially every child might be a George Washington. Practically, however, the attainment of such an ideal might be questioned since it would strip humanity of many of its most cherished illusions and delusions, which, though not always necessary, are on the other hand not absolutely undesirable.

The elements of the prophylactic attitude towards the child lie are epitomized briefly somewhat as follows. In the first place it is necessary for parents always to be truthful with children—even in trifles. It is especially advisable to eschew the conventional white lies which, as has been shown, have such a malevolent effect. Furthermore, the child should never be taught to lie. Those parents who ask their children to tell deliberate untruths are playing with dangerous toys. Over-severity in punishment should be avoided. At its best, it does little or no good; at its worst, it engenders fear, the arch-demon of humanity and one of the paramount causes of the juvenile lie. It is well to encourage the child's imagination, but with caution, since an over-stimulation of phantasy may blunt the child's sense of discrimination between the real and unreal. It is most important to remove from the child as many taboos as possible since these constitute an ever-ready source of transgression. By removing as many *don'ts* as possible we are destroying many embryonic falsehoods. As has been shown it is advisable to

avoid unnecessary questioning, since—unless the questioning is done well and properly—it may lead to unconscious slips in memory, or by dint of suggestion it may force misstatements upon the child, and eventually it might even lead to conscious and deliberate falsehood. Furthermore, it is exceedingly unwise to preach about the evils of falsehood to the immature child. Not only are we confronted here with the danger of magnifying every petty slip from truth, but we also face the possibility of suggesting many undesirable things to the child which it otherwise might not even dream of. Psychologists are well aware that the "don'ts" are frequently the very suggestion leading to the actual violation of a prohibited action. Most important of all is the need of securing the child's confidence and cooperation in the battle against untruth. As Dr. Stern has suggested, "A child who has been taught by its parents the meaning of self-conquest in everything, who has learned to control his anger, to give up pleasure for the sake of others, to own to a fault, even indeed to find a certain satisfaction in self-conquest, will master, too, any temptation to lying ways."

A TRIP TO SANTO DOMINGO

By Professor FRANK D. KERN

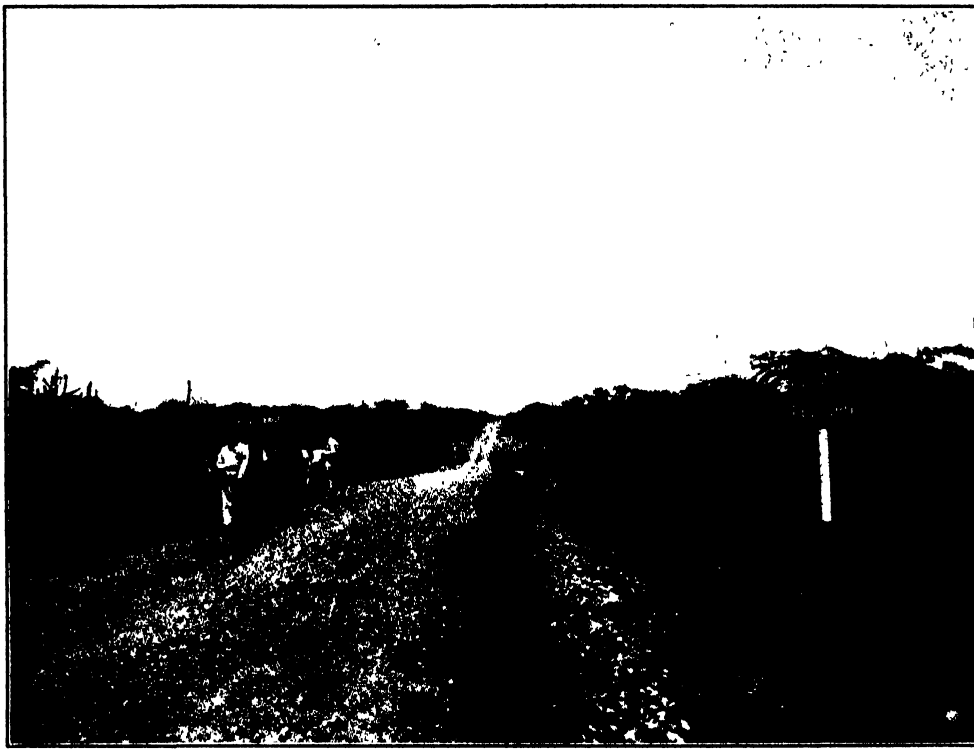
PENNSYLVANIA STATE COLLEGE

HISTORICALLY Santo Domingo is an interesting place and well known. All good students of American history remember that the island was discovered by Columbus on his first voyage to the new world in 1492, that he named the island Hispaniola and that the first European settlement in the new world was made here by the Spanish. It is the second largest of the West Indian islands, being exceeded in size only by Cuba. The Dominican Republic occupies the eastern part of the island and the Republic of Haiti the western part. The Republica Dominicana (official) possesses about twice the area of Haiti, and is larger than Belgium, Denmark or Switzerland, or Connecticut, New Jersey or Massachusetts.

Scientifically, Santo Domingo is also an interesting place but not so well known. With R. A. Toro, of the Insular Experiment Station of Porto Rico, I visited the Dominican Republic during

A STREET SCENE IN SAN JUAN

THE HOUSES ARE TYPICAL OF MANY VILLAGES.



A HIGHWAY THROUGH A DESERT REGION
THE AUTOMOBILE HAS A FLAT TIRE CAUSED BY A CACTUS SPINE.

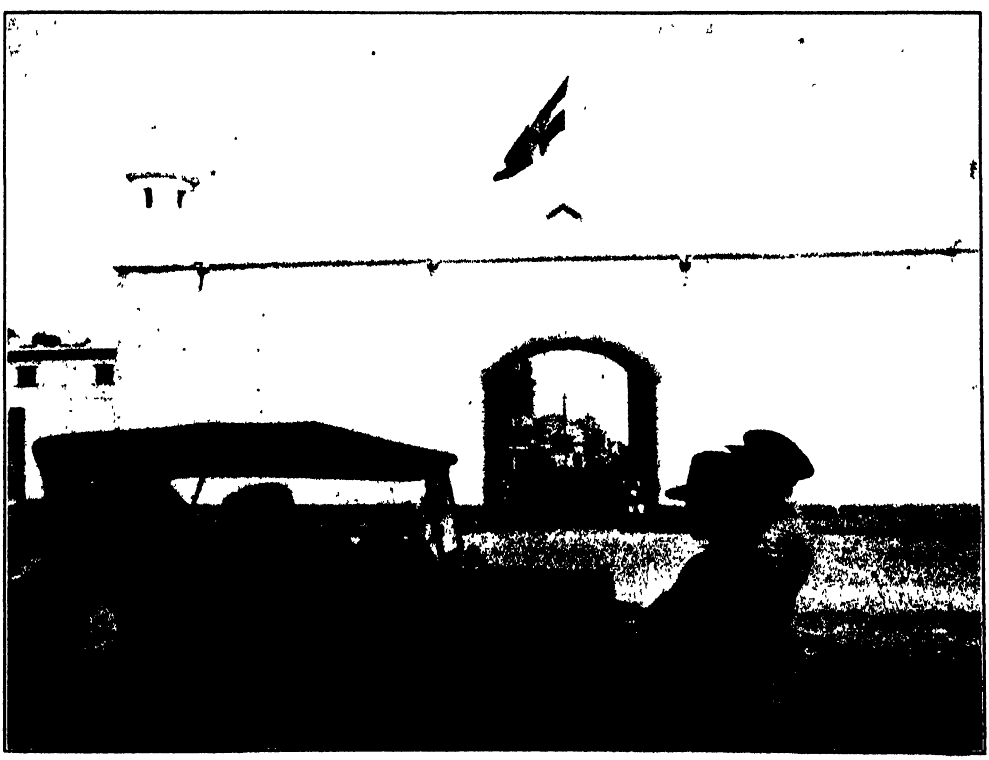
March, 1926, making a study of the plant quarantine situation, observing the plant diseases and collecting fungous parasites of both cultivated and wild plants. I was especially interested in the rusts or Uredinales and my colleague in the black fungi or Pyrenomycetes. While we kept to the field as much as feasible, industriously and minutely examining all vegetation in quest of fungi, we found some general observations possible.

In Santo Domingo city, which is always referred to by Dominicans as "la Capital," we were shown the ruins of the Columbus house, a massive stone house with thick colored walls now in a bad state of repair. We also saw the reputed Tomb of Columbus in the cathedral. The tomb is elaborate and beautiful and in its present form dates from 1892, the four hundredth anniversary of the discovery of America. The cathedral, a fine old structure in Spanish Renaissance style, dates from 1512 and is doubtless the oldest church edifice in the Americas. They have post cards depicting the ceiba tree where Columbus is said to have tied his boat, but they do not show the tree, explaining that it no longer remains. Portions of the ancient walls, with their bastions and gates, characteristic of the Spanish colonial towns of the sixteenth century, are still to be seen in this interesting old city.

Santo Domingo enjoys the same mild tropical climate characteristic of the other large islands of the Antilles. Considerable variations in temperature are caused by the differences in the meteorological conditions and altitude. We

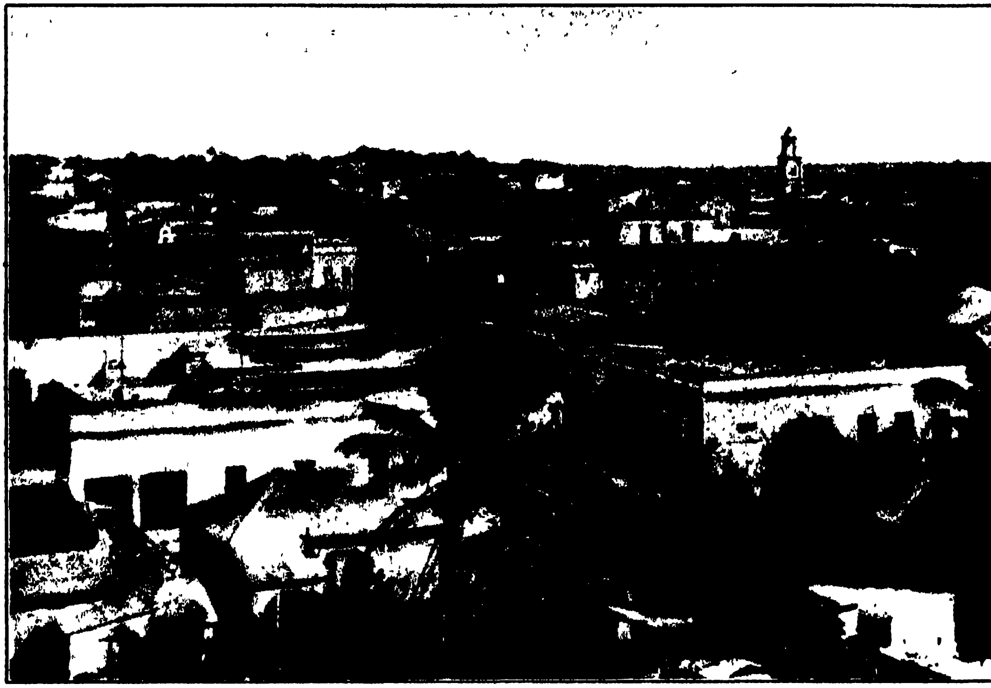
heard a good deal about the cold which prevails at night in the high mountain valley of Constanza. There is no doubt that freezing temperatures often prevail here during the nights of January and February. At the coast in March the days were hot, but the nights were cool and delightful. In the humid sections of the eastern part rains are usually frequent and heavy from May to November. This year they kept up well into January. During the rest of the year the rainfall is scanty. In the western and southwestern sections rain is very scarce at all times, and the vegetation is typically xerophytic, in great contrast to the luxuriant growths of the humid regions.

An excellent highway extends northeast from the capital, on the southern coast, to Monte Cristi on the northern coast. We traveled on this road from the capital to Santiago, the second city of importance in the republic. The surface of the roadbed could be improved in many places, but the survey and grading of the highway are beyond criticism. In passing along this region for an extent of more than one hundred and ten miles one sees great fertile areas that have not yet been agriculturally improved. Further back are other regions, not yet opened up by highways, which can be transformed into productive areas. The successful cane, coffee, cacao or tobacco plantations, occupying only a small percentage of the suitable and available areas, are the best indications of future possibilities. Many tropical fruits grow here with minimum attention. Practically no commercial production of citrus has been attempted.

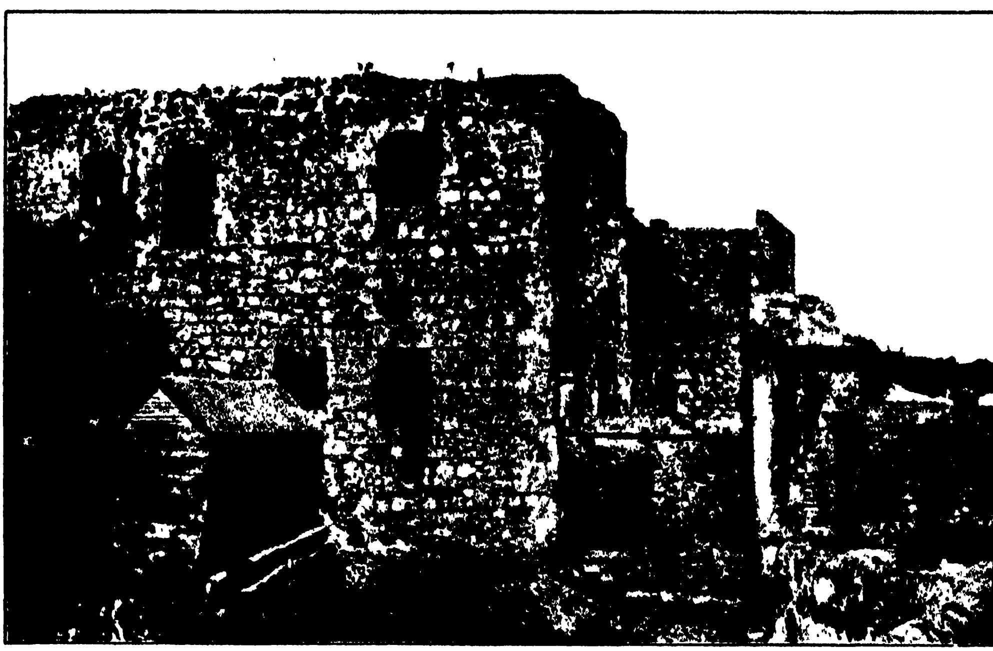


PORTION OF THE OLD CITY WALL ABOUT SANTO DOMINGO

A PART OF ONE OF THE PRINCIPAL STREETS MAY BE SEEN THROUGH THE GATEWAY.



THE CITY OF SANTO DOMINGO, DOMINICAN REPUBLIC



RUINS OF THE COLUMBUS HOUSE, SANTO DOMINGO CITY

PARQUE INDEPENDENCIA IN SANTO DOMINGO

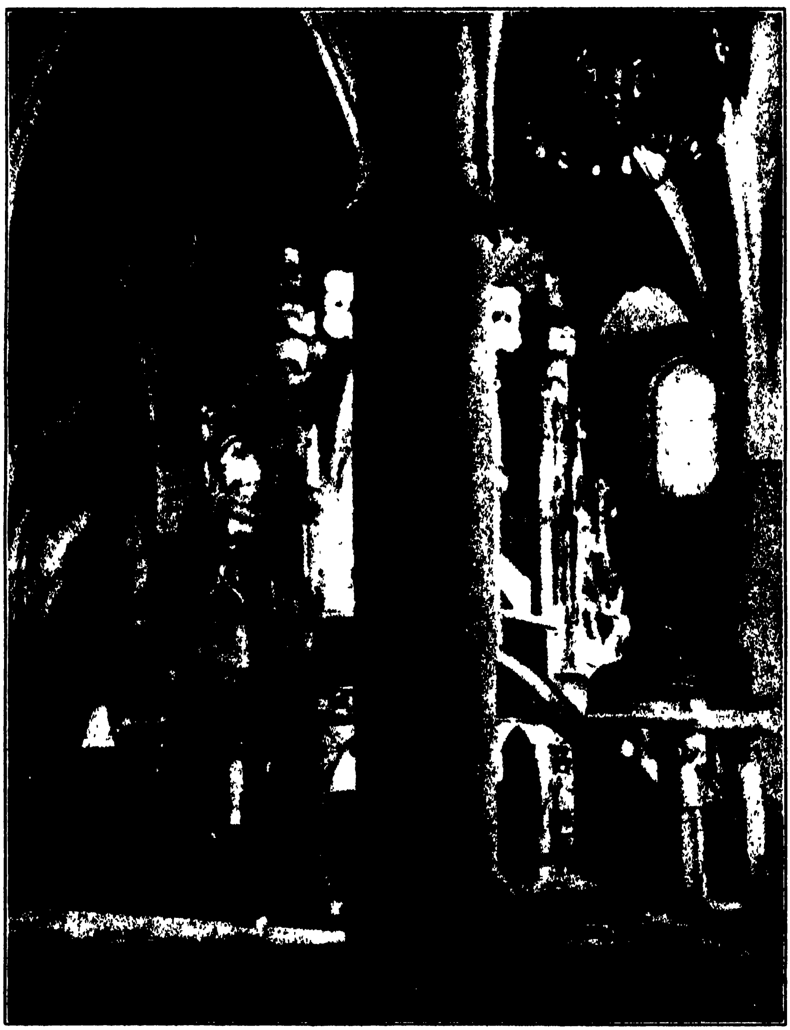
From Santiago the main highway continues to the northwest to Monte Cristi. We were enroute to Puerto Plata, almost due north. A highway is now being constructed from Santiago to Puerto Plata. By special permission of the American engineer we were allowed to traverse a portion not yet open to the public. This allowed us to do some collecting in a region not otherwise accessible but did not help us in reaching Puerto Plata. To do this we were obliged to go by rail, a trip which was scenic and interesting, even if a bit rough and extremely slow. During the night of March 23 at Puerto Plata a shaking of the bed and banging of the shutters was sufficient to remind one that this is a region where earthquakes are likely to occur. We learned later that this same shock was felt in other of the islands and so did not harbor any special grudge against Puerto Plata.

Another trip on the highway which connects Santo Domingo with Port-au-Prince, Haiti, gave us a chance to see some of the dry sections. From the Nazao River westward through Azua and throughout the great valley of the San Juan desert-like conditions prevailed at this season of the year. A third trip eastward from the capital to San Pedro de Macoris and La Romana gave us an opportunity to see some of the finest cane land in the West Indies.

We found Santo Domingo a safe and pleasant place for botanizing. There may be some snakes there, but we did not run across any. The only reptiles we saw were lizards, mostly small or moderate-sized. These little fellows hold a place of their own in the estimation

of most travelers in the tropics. One would certainly miss them if they were suddenly to disappear. In some places in the mountains of Santo Domingo wild parrots are very numerous. A medium-sized green species, variegated with red, blue and yellow, is most common, although we saw a plain black form and also parrakeets.

There are still some fine forests in Santo Domingo. A forest growth here is often made of a considerable number of species adapted to the same conditions and thriving together. There is a great assortment in the sizes and forms of the individual trees, much variation in the density of the growth and no apparent uniformity in the association and distribution of species. Oftentimes it seems that the really valuable kinds are exceedingly scarce, forming a hopeless minority. In other instances a sin-



TOMB OF COLUMBUS,
INTERIOR OF THE OLD CATHEDRAL, SANTO DOMINGO CITY.

XEROPHYTIC VEGETATION
A VIEW SHOWING ITS DENSE AND GNARLED CHARACTER.

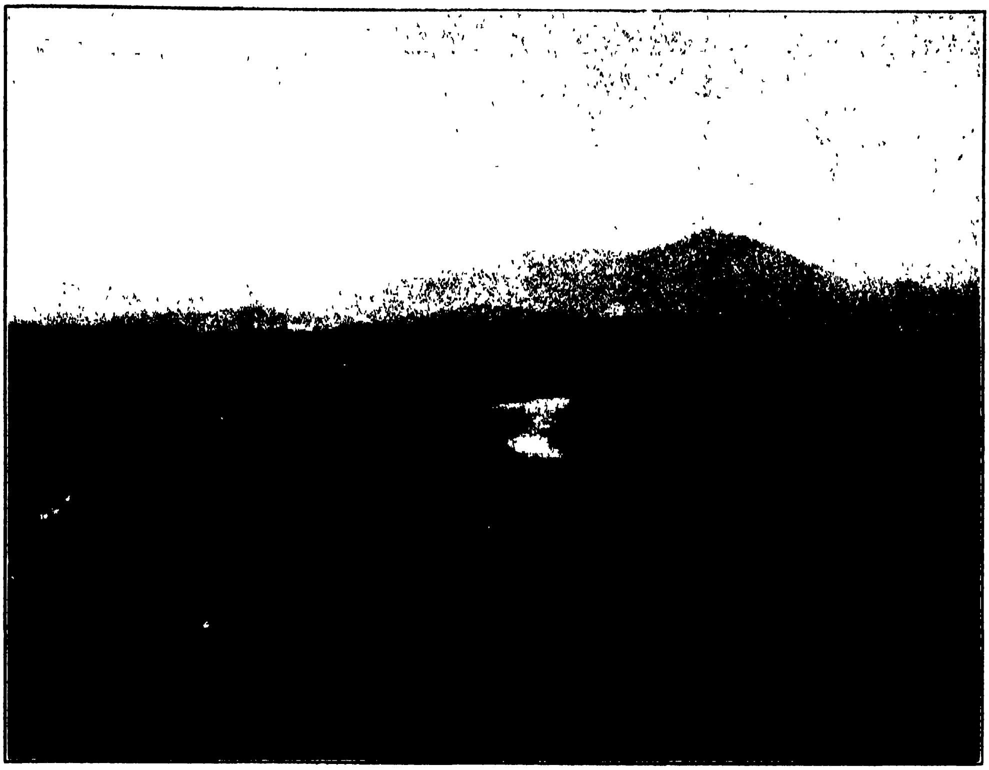
gle species may predominate. This is notably true in certain interior regions, where a species of pine (*Pinus occidentalis*) grows almost exclusively, forming great forests extending over the tops of the lower mountains. Sawmills are now in operation supplying pine lumber for local consumption. In La Vega one evening I was told by a lumberman how important a factor the moon is in lumbering operations. According to his statement lumber cut during the waning moon (*luna menguante*) remains sound and serviceable, while that cut during the new moon (*luna nueva*) is subject to attacks of insects and rots and soon becomes worthless. A belief in the effect of the moon on lumber is quite as well grounded here as its effect on planting and other agricultural operations is in other parts of the world. We did not take opportunity to make any investigations despite the urging of an American engineer, who was present and who insisted that the belief is more than a mere superstition. Other forest resources are mahogany, satinwood, lignum vitae, walnut and logwood.

Santo Domingo had its beginning in a Spanish colony and there is to-day a considerable population with Spanish blood, with a mixture of Negroes of Creole descent. There are also a number of whites of American and European origin and some Chinese who specialize in restaurants. Spanish is the official and predominating language, although English is heard everywhere. This was somewhat of a surprise. In Porto Rico one expects to find English spoken com-

monly, because it has been taught in the public schools for twenty-five years. In Santo Domingo it has not been taught, and yet in the transaction of business, on the streets, in the hotels and everywhere one may hear English spoken. My Porto Rican companion had a good deal of fun at my expense one time and since then claims that it is doubtful whether I understand English. Walking along a narrow street one day I saw indications of a rust on a small tree growing in a yard by a little house. While examining the leaves a woman opened a shutter and said something. Thinking she was likely to say something unpleasant and in Spanish about my being there I attempted to shift responsibility by calling to my friend to come and see what the woman was talking about. I then heard a voice saying, "Come and see what this woman is saying, I am speaking English." Of course I hastily offered an apology. She then told me that she was English. There are in Santo Domingo a good many colored people from the English islands and they all tell you that they are English. The woman just referred to informed me further that she would like to see her Queen Victoria. Needless to add, I did not offer any comment in this connection.

Another amusing incident happened one day when we were riding horseback in company with the mayordomo of the plantation where we were stopping at the time. My friend and the mayordomo were some little distance ahead of me. Suddenly I saw a man further down the

THE LARGER CACTI
WHICH ARE COMMON IN THE DRIER AREAS.



A TYPICAL VIEW OF THE INTERIOR OF THE ISLAND LOOKING TOWARD THE MOUNTAINS

road pointing a gun in our direction. I heard him say something to the two ahead of me but at the distance could not understand. I saw the two rein their horses quickly to the side and before I could act I heard a shot. It is true that for the moment I thought it might be something more serious than the shooting of a pigeon, but it is not true that I held up my hands and shouted "Una revolución," as my companion relates.

Dominican money consists of coins only. The unit is the "*peso dominicano,*" a large coin about the size of a silver dollar but worth only twenty cents. United States money is the standard of value and can usually be had in change. One soon tries to avoid the native coins, which run into such bulk, representing as they do only one fifth the value of our corresponding pieces.

Observations and studies were made of the diseases of economic crops, especially from the point of view of the plant quarantine situation in Porto Rico. No diseases were found on any of the crop plants which do not already exist in Porto Rico. Some of the staple crops were found to be particularly free from serious diseases in Santo Domingo. The coffee plantations visited were notably free from diseases. Cacao is an important crop and was also notably clean. Sugar cane, which is the major crop, was in most places very seriously affected with mosaic. In some places certain varieties showed 100 per cent. infection. We were convinced that sufficient attention had not been given by cane growers to efforts to control this disease. They

are apparently beginning to give attention to the matter of clean seeds and resistant varieties. Some other diseases of cane appeared to be less prevalent than in Porto Rico. The chamaluco variety of banana is disappearing because of its susceptibility to the wilt disease. However, other varieties of banana are more resistant and they are cultivated more extensively.

Approximately four hundred collections of fungi were made and have been preserved for further study and investigation. It is expected that these studies will yield some interesting information for comparison with the better known regions of Porto Rico, the Virgin Islands, Cuba, Jamaica and Central America. An expedition undertaken during the rainy season of the so-called summer months would be likely to be productive of better results, even though it would be beset with more difficulties in collecting. In our work we were very generously and effectively aided by the Secretario de Estado de Agricultura e Inmigración, the Director de la Estación Agronómica y Colegio de Agricultura, by other civil and military authorities and by numerous private citizens.

Before going to Santo Domingo we were told by some good friends that it was a land where people rode on the highways astride of oxen, that the movie films had only Spanish legends, and that the people smoked only big black cigars which were strong and expensive. On the contrary, we found that they ride burros, that the movies have English as well as Spanish legends and that most of the natives smoke pipes, although good moderate priced cigars are available. Our experience leads us to conclude that a country, as well as a man, sometimes may be unintentionally maligned by perfectly well-meaning persons. We were glad we had the opportunity to investigate for ourselves.

THE STORY OF THE STONES IN THE DOMINION PARLIAMENT BUILDING

By Dr. E. M. KINDLE

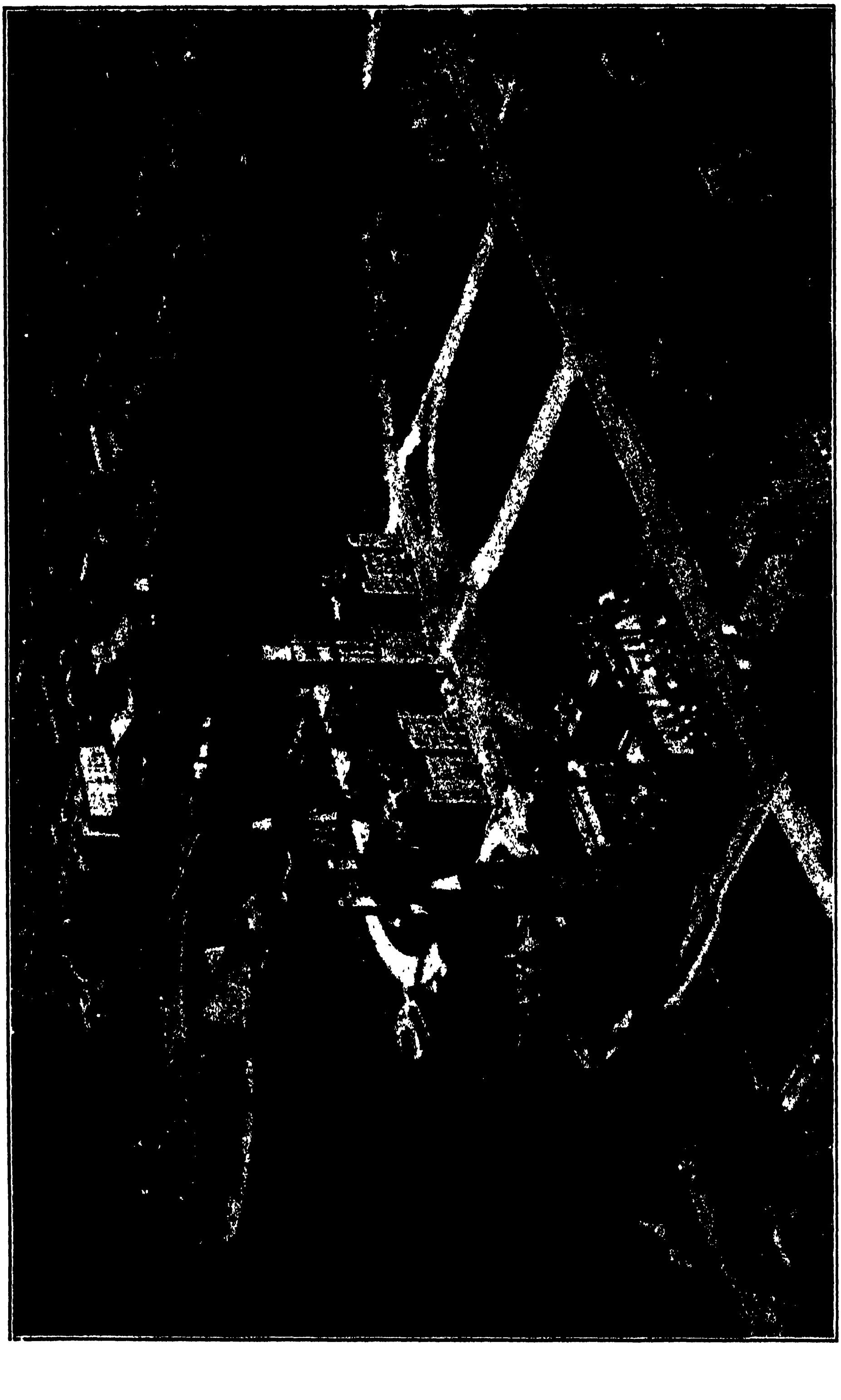
GEOLOGICAL SURVEY OF CANADA, OTTAWA

THE new Parliament building in Ottawa displays in its beautiful Gothic lines good examples of some of Canada's best known building stones. The fossils in some of these record singularly well certain parts of Canada's prehuman history. The walls and spires of this splendid building exhibit to the best advantage the beauty of Canadian building stones from provinces as far apart as Quebec and Manitoba. The creamy mottled limestone of Manitoba, with its fossils sectioned in various directions by the stone cutter, and the green serpentine from southern Quebec may be seen in the corridors of the building, while the outer walls are constructed of Cambrian sandstone from quarries a few miles to the southwest of Ottawa. Inside the base of the Memorial Peace Tower Flemish marbles have been used. Certain combinations of serpentine and marble furnish the verde-antique marbles which are also represented in the interior of the building; but it is with the story of the Manitoba limestone and the much older Cambrian sandstone clearly written in hieroglyphics quite legible to the paleontologist that we are here concerned.

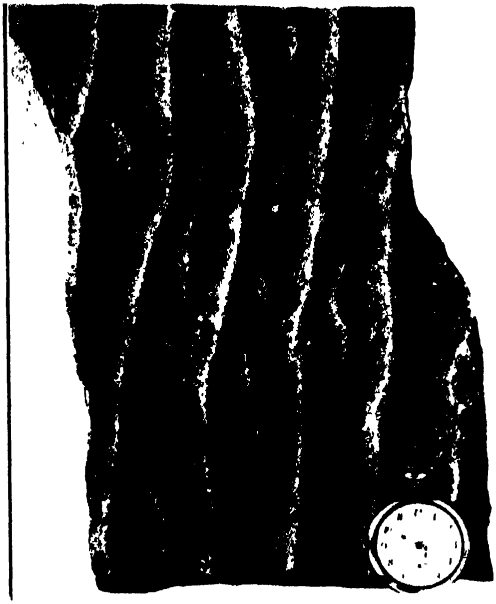
SIGNIFICANCE OF THE CAMBRIAN SANDSTONE

Very considerable fragments of certain chapters of the great stone book, from whose pages the geologist reads the story of the world, have been assembled in the walls of this building. The oldest and most extensively used of these fragments of the past are the sandstone blocks of the outer walls. These came from the Potsdam sandstone of the Ottawa valley, which is a formation of Cambrian age. Thus quite unintentionally the architects have invited visitors with the enquiring type of mind to make a little journey in time.

The formation of the Potsdam sandstone is so far back in the geological ages that the mental journey essential to restoring a picture of Cambrian times in the Ottawa valley should be made in stages. The depression of the Ottawa and St. Lawrence valleys, which some 15,000 years ago submerged Parliament hill under 200 feet of sea-water, seems remote in time as compared with recorded human history. But the long slow creep of the northern ice cap, which for unnumbered thousands of years moved southwards over the continent to the middle of the United States and finally retreated as slowly as it came, preceded this great westerly incursion of the Gulf of St. Lawrence. Even the coming of the continental ice cap more than 100,000 years ago the geologist thinks of as a relatively recent event, for the great ice sheet found the Ottawa and St. Lawrence valleys in their broader features much as they are to-day. It is only when we go back to such an event as the birth of the Gulf of Mexico and the coincident appearance above the sea of the southeastern corner of the continent which added Florida and the southern half of the Gulf states to North America that we begin to get the geological perspective essential to considering the earlier reaches of geological time.



THE DOMINION PARLIAMENT BUILDING FROM THE AIR



OSCILLATION OR WAVE-MADE RIPPLE-MARK WITH SMALL MEDIAN RIDGES BETWEEN MUCH STRONGER ANGULAR RIDGES ON CAMBRIAN SANDSTONE, HAMMOND, N. Y.

Three million years ago in Pre-Florida or Eocene times the present site of Chicago was 575 miles nearer the sea to the south of it than at present. The head of the Mississippi Gulf, forerunner of the Gulf of Mexico, was then near the site of Cairo, Illinois. This phase of American geography coincides with the dawn of the stage of earth history which geologists call the Cenozoic or the era of modern life. Near relatives of modern plants and animals were then in existence, including the fox-like progenitor of the modern horse.

But the outer walls of the Parliament building carry us back through the deeps of time to the early Paleozoic when no animal with a backbone had appeared on the earth. Plants more highly developed than algae did not then exist. Neither plants nor animals had in Cambrian times become fitted to live on the land. Not till ages later had plant life developed to such a stage that its accumulated remains became sufficiently abundant and of suitable kinds to produce the materials for beds of coal. The paleontologist is therefore able to predict with confidence that coal will not be found in rocks containing Cambrian, Ordovician or Silurian fossils. Such predictions are entitled to the same confidence which is generally accorded the astronomer's announcement of an eclipse of the sun. Unfortunately for the hapless investor in bogus coal prospects the advice of the paleontologist is not sought as frequently as it should be. This may result from the fact that the general principles underlying astronomy are better understood than are those which form the basis of paleontology.

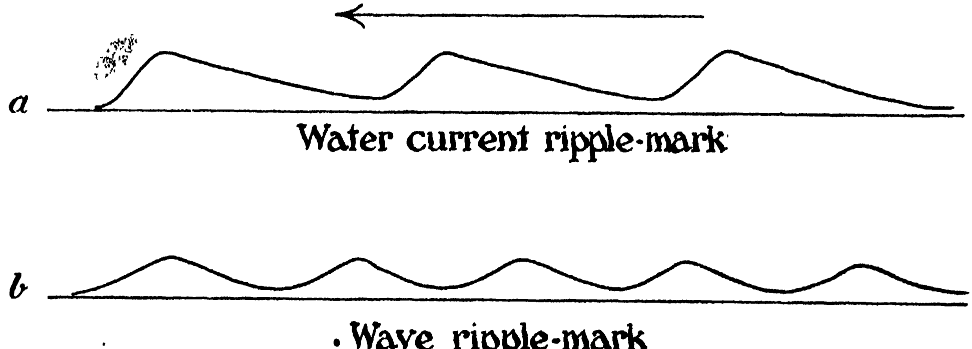
It is a fundamental principle of geological biology that the several kinds of animals and plants die and eventually pass off the stage of time to be followed by other different but related kinds. Just as the individual animal has a lifetime of ten or one hundred years, so the species has its life span of 10,000 or 100,000 years or more and disappears from the living world but leaves the record of its life—when it came and when it went– in the rocks. There is one case, however, which comes near being an exception to this law. *Lingula,* a simply constructed little shell of the present seas, is one of the forms of life which time forgot or almost failed to change, for in the sandstone from which the Parliament building is chiefly constructed there is a small shell called *Lingulepis* which is almost but not quite the same as the living Lingula. The occurrence here of this very ancient ancestor of the modern *Lingula,* which has defied successfully the bounds of time set for nearly all other types of life, lends a peculiar geological interest to the Cambrian sandstone in the Parliament building.

These sandstones contain but little evidence of the life of the early geological period which they represent beyond these linguloid shells and broad trails, which remind one of an automobile track. These trails were made by a creature still unknown. Good examples of them may be seen in the National Museum at Ottawa, labelled *Climactichnites wilsoni* Logan.

It must not be inferred because the known fossils of the Potsdam sandstone are limited to a Lingula-like shell and the trail of a huge but unknown mollusc that life was scarce in the Cambrian sea, which this sandstone represents. It is well known to naturalists that the sandy bottoms of the present seas are comparatively lifeless, and the shifting sands of the Cambrian seas were, as the Potsdam sandstone indicates, equally unfavorable to life. Where other types of bottom prevailed a host of strange creatures, among which trilobites were most conspicuous, flourished.

The Potsdam sandstone has preserved a record of its physical history which is full and complete as compared with its scanty biological record. The pure white sand with ripple marked layers and occasional bands of well-rounded pebbles tell the story of its origin as plainly as a printed page. These sands were deposited in a sea bordering the southern margin of the oldest known land in Canada, which occupied approximately the position of the Laurentian highlands or the Canadian shield. The sand of this formation came from the decay of the granites and gneisses of this old V-shaped land mass which now holds Hudson Bay in its arms and reached the sea by rivers which are known only by the sandstone formation which they gave to the young continent.

The fossil ripple marks found at various levels in the Potsdam sandstone have recorded both the waves and the currents which were engaged in the work of spreading the sands over the old Cambrian sea bottoms. Waves and currents make distinct types of ripple-mark—the one symmetrical, the other asymmetrical. Both types are found well developed in the Potsdam sandstone. Current or asymmetrical ripple-mark always trends at right angles to the direction of the water current which produced it, and the direction of the oscillation or wave ripple-mark is at right angles to the waves and the winds responsible for its formation. It is, therefore, possible at any exposure of the Potsdam sandstone where good fossil ripple-mark can be seen to tell the exact direction of the tidal currents and the trend of the sea breeze when the sands of a particular bed came to rest on the sea bottom. The autographs of the Cambrian sea breezes and tidal currents



DIAGRAMMATIC CROSS SECTIONS OF WATER CURRENT (*a*) AND WAVE MADE (*b*) RIPPLE-MARK.

inscribed on the Potsdam sandstone more than thirty million years ago are just as legible as those now being inscribed on the sandy beaches of the Atlantic coast.

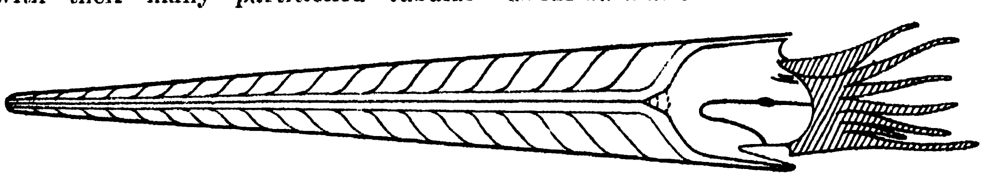
The sands which became the Potsdam sandstone when consolidated were a near-shore deposit of a Cambrian sea which stretched across northern New York state into southeastern Ontario. The argillaceous and deeper water sediments of other facies of the same sea bottom and their richer fauna are probably all buried under younger rocks, but even where Cambrian life was most luxuriantly developed it gave no hint of the coral and cephalopod life which followed it in the next geological era. These we find abundantly in the Manitoba limestone.

The Manitoba Coral Seas

Far more novel in appearance than any of the fantastic gargoyles about the Parliament building are the fossil molluscs which adorn some of the blocks of Manitoba limestone in the corridors. Many of these fossil animals are so remote from modern forms of life or structure as to be scarcely reminiscent of them. The visitor who is curious about the ancient life of this continent must go to the National Museum to see Canadian dinosaurs, but sections of the no less strange Manitoba cephalopods or devil fish, which disported themselves some thirty million years ago in the Ordovician seas where now the Manitoba wheat fields stretch away to the horizon, may be seen in the corridors of the Parliament building. These great shell fish with their many partitioned tubular shells were progenitors of the modern pearly nautilus.

Oliver Wendell Holmes' poem "The Chambered Nautilus" has made familiar a plan of structure which begins with the venerable Cephalopod dynasty of early Ordovician times. Their living descendants and relatives include besides the sea squid and the Pearly Nautilus, the Paper Nautilus which was once believed to come to the surface at times and "spread to the wafting breeze a two-fold sail." This pleasing fancy of the days of Aristotle has however been dispelled by the naturalists. The Nautilus is now known to swim rapidly by projecting a current of water through a funnel-like organ. The Ordovician cephalopods doubtless swam in the same way making "headway back foremost."

Sections of some of the corals which lived in the ancient seas of Manitoba may also be seen in the Parliament building corridors, together with brachiopods and various other fossils which date the stone blocks holding them back many millions of years before the time of either men or Parliaments. One may speculate but can never know about the many other strange creatures without hard parts capable of fossilization which were probably contemporaries of the corals and the cephalopods. Some creatures of our present seas without any hard parts which can leave a record after death are in many cases among the most curious of modern animals. Some of the jelly fishes glow at night with a soft blue light and we know by one fortunate discovery made by Dr. C. D. Walcott that this type of animal appeared as far back as the Cambrian. Other soft-



A DIAGRAMMATIC LONGITUDINAL SECTION OF *Orthoceras*—AN ORDOVICIAN CEPHALOPOD.

bodied creatures like the tunicate colony called *Pyrosoma* emit when stimulated a bright light, and one naturalist records writing his name with his finger on the side of a pyrosoma at night which came out a few seconds later in letters of fire. It is probable that the Ordovician sea of Manitoba possessed like modern seas many phosphorescent animals. The Manitoba sea may have often shown at night waves flashing with a weird dull blue light. They may even have rivalled Professor Hickson's description of a dark night on the Banda seas when "the water is often like a huge expanse of pale blue smoke studded with diamonds and other lustrous gems." Whether or not phosphorescent animals lent their magical colors to the Ordovician seas which produced the mottled limestone of Manitoba, the corals themselves must have supplied, as modern corals do, a rich variety of colors. Dull brown and green tones are characteristic of the coral reefs of the present subtropical seas, but these are often varied with bright violet growing points in the branches of the Madrepores. Orange or red fan corals, bright brick red sponges, emerald green organpipe corals and scores of other forms of life also add their contribution to the riot of color which accompanies the coral reef of to-day. Since most modern corals after the decay of their soft parts give no hint of their colors in life, we can not expect the Ordovician fossil corals to supply any evidence of their living colors except by analogy. But it seems a safe inference that the corals which furnished much of the material of the Manitoba limestone contributed to the shallow Ordovician seas of Manitoba a wealth of color and beauty in which green, brown and yellow were prominent.

In the rocks which underlie the prairies of western Manitoba, Saskatchewan and Alberta is recorded the story, much too long for these pages, which Canadian geologists have deciphered of the transformation of the old Ordovician coral seas of Manitoba successively into the Silurian, Devonian and still later into the early Cretaceous seas with their ammonites. Later yet came the marshes and sea-side lagoons of western Canada with their dinosaurs, but this was long before the birth of Florida and the Gulf of Mexico.

The Cultural Aspect of Geology

After making the little journey in time which the stones of the Parliament building suggests, the visitor should be able to pursue with a more discerning eye the little journeys into politics and human history which this building may also inspire him to undertake.

In place of the finished world of a few generations ago we now recognize a constantly changing world which has been tenanted by an endless succession of plants and animals, each unlike and a little in advance of those which preceded it. The geography of to-day we now know to be no more permanent than the cloud forms of yesterday. Familiarity with geological concepts has contributed enormously to mobility of mind and broad intellectual hospitality. The man who can visualize clearly the physical geography of Canada as it has been in the remote past is prepared to comprehend as well as to meet and direct the great changes incident to the evolution of the social, economic, and political world in a way that his brother who still lives in the finished world of yesterday can not.

A MOUNTAIN SOLAR OBSERVATORY

By Dr. C. G. ABBOT
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Does the sun vary in its output of rays available to heat the earth? If it does, the weather must vary in some way depending thereon. Hitherto meteorologists have not used this element in making their predictions because the necessary solar studies have not been available. For the past eight years the Smithsonian Institution has been endeavoring to supply this lack by maintaining stations in Chile and in the southwestern United States, where almost daily measurements are being made of solar heating.

It is not the variations of sun-heat as found at the earth's surface that are in question, for these depend on the haziness and humidity of the atmosphere much more than on real solar changes. The measurements must be made in such a way as to eliminate atmospheric losses and to give the true value of solar radiation as it is in free space at the earth's mean solar distance. This quantity is usually called the solar constant of radiation, and we shall call it so in this article.

The average value of the solar constant for the past twenty years appears to be 1.94 calories of heat per square centimeter per minute. Fluctuations from this mean value as great as 3 or 4 per cent. in both directions, or a range of 6 or 8 per cent. seem to be found. These changes are of two types. One runs over long intervals and is definitely associated with the sunspot activity. Apparently the solar constant averages 2 or 3 per cent. higher at times of sunspot maximum, that is to say, at intervals of approximately eleven years. Again, there seem to occur short interval changes running their course in a few days or weeks. Often these seem associated with the central passage with solar rotation of sunspot groups over the solar disk. Low solar constant values occur at such times for several days.

Hitherto, the average accidental difference between the daily measurements of the two Smithsonian stations, situated four thousand miles apart, in the United States and Chile, has been about 0.5 per cent. But on a good many days the differences are considerably larger, and on many days one or both stations fail to observe because clouds interfere.

This matter of the variation of the sun concerns the whole world. In order to make the determinations of the solar changes more complete and accurate, the National Geographic Society has given to the writer a grant of $55,000 to use for three purposes: (1) To select the best site in the eastern hemisphere for locating a cooperating solar observatory; (2) to procure the necessary equipment, including the construction of buildings, roads and apparatus; (3) to carry on daily solar constant work for a period of about four years.

There are several determining considerations. An isolated mountain site in a desert country is needful in order to diminish effects of dust, haze, smoke and cloudiness. Easy communication is required for installing and maintaining the station and for securing daily telegraphic reports of results. Governmental conditions must be stable and firm enough so that the observers need not fear assassination and confiscation. Many minor considerations add to the difficulty of a choice of site.

After consulting available meteorological data, conditions seemed most promising in Algeria, Baluchistan and Southwest Africa. Accompanied by Mrs. Abbot, I left Washington on October 30, 1925, and journeyed by way of England, France, Algeria, Egypt, India, Baluchistan, South and Southwest Africa, and arrived at home on April 26. We were gone almost six months and traveled nearly thirty thousand miles.

In Algeria, the Djebel Mekter, about seven thousand feet high, and four miles south of the French military post of Ain Sefra, was examined. There is a stone building on its summit formerly used as a heliograph station, and which might have served as both dwelling and observatory. A well-graded rocky road leads up to it.

The impressions of a French officer, Captain Navarre, who had been stationed at Ain Sefra for five years accorded well with recorded daily observations kept by a soldier as to the cloudiness of the region. It seemed probable that during January, February and March many days would be lost, leaving a minimum of at least ten days per month favorable. During the remaining nine months, upwards of twenty nearly cloudless days per month could be confidently expected.

A local contractor was ready to repair the building and the French government and military authorities were cordial to the proposal of establishing the observatory there. However, a still more favorable condition as to cloudiness was hoped for.

A few days were spent in Egypt, and inquiries made of several English scientific men at Cairo as to the possibilities of finding a good location in that sunny country. It appears, however, that mountains high enough to avoid dust and haze are inaccessible in Egyptian territory.

Arrived in India, we were hospitably entertained at Delhi, and provided with recommendations to the authorities in Quetta, Baluchistan. There we were most kindly treated and assisted, especially by Colonel and Mrs. Trench, of the Political Agency, and by Colonel Barker, of the Royal Engineers. Although Baluchistan is far from being a calm, humdrum country, it was decided that the observatory might be located with considerable safety on Khojak Peak, seven thousand five hundred feet high, and about ten miles from the Afghan border.

As the military rule requires that autos on the road to the peak must carry a loaded rifle, and not less than two persons besides the driver skilled in using it, I was not surprised to be informed that the observers would not be permitted to reside at the peak, but must be quartered at Shelabagh, a garrison town three miles east. Two native soldiers would be required to watch the observatory, and a third to ride to and fro daily with the observers. Owing to the caste system, cooks will not sweep, nor valets serve, so that several servants besides the soldiers would be needed to keep up face in a country where no white man is supposed to lift a handkerchief.

Thus quite a staff of dependents must be attached, and this with large expenses associated with the immense distance from Washington, and the costliness of construction and supplies, and the uncertainty of relief from customs duties, tended, with the separation of dwelling quarters, to counterbalance the advantages of an apparently excellently clear and cloudless sky.

Arrived in South Africa, a stay of ten days in Johannesburg was made while official connections were being established and inquiries made. Dr. Innes, of the Union Observatory, and Dr. Alden, of the Yale Observatory, as well as Mr. Donald, the United States consul, and the vice consul, Mr. Hall, all exerted themselves to aid and entertain us.

Valuable information as to conditions in Southwest Africa was given by Dr. Reuning, formerly geologist for the German government of Southwest Africa.

Arriving at the capital, Windhoek, Colonel Venning, director of posts and telegraphs for Southwest Africa, introduced me to other officials. It was soon decided that the best location is the Brukkaros Mountain (Lon. 17° 48′ E., Lat. 25° 52′ S. Alt. 5,202 feet. General level of the plateau surrounding, 3,000 feet).

This mountain lies near Berseba, the principal town of the Hottentot reservation. An affirmative vote of the Hottentots was necessary to permit its occupation. The railway division town of Keetmanshoop, about sixty miles to the south, will be the point of supply.

The Brukkaros is a very small cup-shaped mountain rising precipitously two thousand feet above the plateau which extends almost level for fifty miles in every direction. The average rainfall there is three and one half inches, occurring one third in February, one third in March and the balance scattering.

It is very favorable to the cooperation of this station with our other two that December at Brukkaros is fine and January but little cloudy. These are the worst months at our other stations. I was near the Brukkaros for twelve days in the height of the rainy season. Of these the forenoons of eleven days were excellent for our observations. There is great hope that upwards of 90 per cent. of all days of the year will be available there.

The clearness of the atmosphere is very fine. One notes almost no perceptible haziness in looking out over the plateau to the horizon. Even as seen from low-lying stations, the stars go down without becoming dim and disappear suddenly as if occulted, while still retaining their brilliance. On the Brukkaros the sky was of a deep blue right up to the edge of the sun.

During my stay in the neighborhood there were no heavy winds, hardly, indeed, the slightest breeze, but I was told that there were occasionally in winter some days of strong wind. Yet the desert in that neighborhood has so coarse and stony a texture that sand drifts are not to be seen.

Our proposed observatory site is situated near the southwestern summit, but inside the rim of the cup-shaped mountain, so that the configuration itself will tend to reduce the force of such winds as may sweep the plateau. The observatory rooms, as in our other stations, will lie in a horizontal tunnel about thirty-five feet deep in the rock. The sun-beam is reflected in with a coelostat carrying stellite mirrors which never tarnish.

Within the tunnel is the spectroscope and the bolometer-galvanometer combination, capable of observing and automatically recording the heat of the spectrum rays to the millionth of a degree rise of temperature. Outside are the pyrheliometers and pyranometer for measuring directly the heat of the sun and of a small ring of sky immediately surrounding the sun. With the findings of the three types of instruments combined, two observers may determine the solar constant five times independently in a single morning of observation and may get the results computed by early afternoon.

The station was begun in April under the supervision of Mr. A. Dryden, inspector of public works for the Southwest African Government. Apparatus had been procured in Washington, and it was planned to send out the expedition in early autumn under Mr. W. H. Hoover, director, and Mr. F. A. Greeley, assistant. Observing could begin within a month of arrival on the ground.

Meteorologically, the location seems superb. It is very isolated. No neighbors are nearer than the Hottentot village of Berseba, seven miles away, and there are but two white people in Berseba. The supply town is Keetmanshoop, sixty miles or three hours distant by auto. This is a pleasant place, a railway division point, with bank, hospital, churches, clubs, hotels, schools and general stores.

Provisions must all be brought by auto and mule-pack. Water sufficient, but not plentiful, can be had on the mountain itself, though nearby barren, tufted grass sufficient to maintain much game covers the desert. What with occasional visits to town, books, games, radio, music, hunting and interesting work, the observers hope to be contented to stick out their three-year terms. Of course the opportunity to see the world counts with them in going to this remote corner.

The trail, the tunnel, living quarters, garage and two cemented reservoirs were completed by Mr. Dryden early in September. The expedition landed at Capetown on September 13. Providing all has gone well, observing should have commenced on the Brukkaros by November 1, 1926.

Cooperative observing by three desert-mountain solar-radiation observatories, under one management, is now assured for several years. Yet the next generation will be at loss as much as we are, to answer the question whether solar variation is an important element of weather, unless financial support sufficient to continue the Smithsonian measurements in future years quickly becomes available.

THE METRIC SYSTEM OF WEIGHTS AND MEASURES[1]

By Professor A. E. KENNELLY

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We all know how simple is our system of money based on dollars and cents. We realize that its simplicity depends upon the ten-to-one or decimal relation of its parts. There are ten mills to a cent, ten cents to a dime and ten dimes to a dollar. All sums of money are thus expressed in dollars with decimal steps.

Unlike our money, our system of weights and measures is complicated and difficult. The ten tables taught in our schools comprise about fifty different units, not decimally connected. Very few people can say these tables from memory, without a mistake. The tables taught in English schools comprise about sixty units. Most of the corresponding American and English units are the same; yet there are fourteen that have different meanings. These are the hundredweight and ton, which are long in England but usually short with us, the pint, quart, peck and bushel in dry measure, the minim, dram and ounce of apothecaries' measure, likewise the gill, pint, quart, gallon and barrel in liquid measure, all of which are respectively about 20 per cent. larger in Canada and the British Empire than in the United States. We still keep the old wine gallon of Queen Anne; while the British changed about one hundred years ago to the imperial gallon. All these fourteen units are ambiguous, and they frequently lead to misunderstandings.

In order to clear up similar complications, the French introduced, about the year 1800, a new system, which they called the metric system because it was based on a certain new standard yard, called the meter. The meter is only roughly a yard. It is about 10 per cent. longer than our yard. They applied the ten-to-one or decimal steps to this meter, just as in our decimal money system. The metric system came into general use in France about ninety years ago. It was found to be definite and easy. They called one thousand meters a kilometer, from the Greek word for a thousand, and this serves for the measure of great lengths. A kilometer is thus one thousand world yards, or very closely one thousand one hundred of our yards. One may travel all over continental Europe, by either highway or railroad, and find the distances marked off in kilometers. During the great war, two millions of our young men visited France, and so came into contact with the use of the metric system. Since their return to the United States, there has been a distinct increase of popular interest in the metric system. About twenty-five years ago, the advocates of this system were mainly scientists; but since the war, mainly business men. There are only three main units in the metric system—the meter, the gram and the liter. The rest are optional names for decimal steps. Thus the distance from Boston to New York, by the New Haven railroad, is 369 kilometers; but that is only another way of saying 369 thousand meters.

The great advantages of the metric system are its widespread international use, its simplicity and its uniformity all

[1] Given to the air from Station W.E.E.I., Boston, 1926.

over the world. We know that there are two kinds of tons, three kinds of quarts and many bushels; but there is only one meter. This is because there is only one meter standard, which is preserved in an underground vault in the International Bureau of Weights and Measures at Sèvres, near Paris, France. In 1872, France donated a small old royal palace and twenty-five thousand square meters of land to the International Bureau for this purpose. The old palace at Sèvres stands within the old royal park of St. Cloud. Princess Mathilde once lived there. It is not far from the famous Sèvres porcelain factory, and it has been relinquished by France to international jurisdiction. Presumably, it pays no taxes, and a French policeman could make no arrest there. Facing the old palace, or pavilion, a new laboratory building was erected in 1875, with double walls, to keep the internal temperature nearly uniform all the year round. In this laboratory, copies of the international meter bar are made and compared. Each bar is of special platinum alloy, which preserves an untarnished silvery surface. A standard bar has two scratches cut across its face with a diamond, one at each end. The distance along the bar, between these scratches, is set for one meter, when the bar is kept at the temperature of melting ice. Various working copies of the standard meter are kept in the laboratory; but the standard itself is deposited in the vault, eight meters deep below ground. The vault is opened once every six years, in the presence of witnesses, to demonstrate that the standard meter and standard kilogram are in safe preservation. Twenty-eight countries jointly maintain this international bureau. Four special keys are successively needed to open the vault, and three of them are in the custody of foreign delegates to the International Committee; so that the vault can only be opened when the committee meets at six-year intervals. During the great war, one of these keys was in Germany. If it had been necessary to open the vault during the war, it could only have been done by breaking in. Platinum alloy copies of the meter have been distributed among the nations of the civilized world. They are believed to have been correctly compared with the standard at Sèvres, to a precision of at least one part in five millions. There are two of these certified standard meters in the United States, and all our accurate measures of length in industry and in surveying are ultimately connected with these standards. Such standard bars are treated with the greatest care, lest they should be injured by a jolt or fall. Occasionally such national copies of the international meter are returned to Sèvres, for recomparison and check. In all these cases they are taken by a special messenger. It is no wonder, therefore, that the meter has the same length in all parts of the world.

All the civilized countries of the globe have successively either adopted the metric system in their everyday life or they have taken steps officially to do so in the near future, the English-speaking countries only excepted. But although the English-speaking countries have not yet taken any official action towards the general adoption of the system yet an impartial inquiry into the history of the last thirty years will probably show that we are actually already in process of gradual transition to the metric system, though how many years it will take to make the transition complete no one can say without the gift of prophecy. Substantially all the precise American scientific work is now carried on in the metric system. A few departments of the U. S. government use the system every day; namely, the Coast and Geodetic Survey, a part of the U. S. Customs, and the medical departments of the Army and Navy. There is at least one Amer-

ican industry that uses the system exclusively; *i.e.*, the business of making lenses for eye-glasses and spectacles. All such lenses are prescribed and constructed in the metric system. Many thousands of monthly bills to consumers of electricity for electric light and power are made out in terms of the kilowatt-hour, a unit based on the metric system. All our radio wave-lengths are measured and specified in meters. A few American manufacturing firms have voluntarily changed over to the metric system in their factories, for the sake of convenience and simplicity. Their testimony has been that while there was a certain inconvenience and bother in making over lists, schedules, drawings and stock-sheets for a little while after the change, the cost was trivial, and no machinery had to be discarded. Our coinage is associated with the system; because a new nickel, or five-cent piece, weighs just five grams, and our silver coins, from the half-dollar down, weigh at the rate of twenty-five grams to the dollar.

Out of the twenty-five large countries and more than fifty little ones that have already given up their original systems and adopted the metric system, none has ever revoked its decision.

A large element of the steadily increasing trend towards the metric system in our country doubtless comes from the fact that modern communication has greatly increased the interchange of methods and ideas between the nations through the telegraph, the telephone and radio.

The invisible radio waves spread from a transmitting station, in all directions, with the enormous speed of light. The radio waves now carrying my voice far and wide are believed to spread over the globe and to reach the furthest opposite point, or antipodes, near Perth in Western Australia, in about one tenth of a second of time. The waves from WEEI in Boston have not yet been picked up in Australia, so far as I know; but I am informed, through the courtesy of the officers of WEEI, that the friendly voice has been caught and identified by radio receivers in various remote places as far west as the Pacific coast and as far east in Europe as England, Belgium and Sweden. In the case of more powerful radio-telegraph stations, signals have often been received at or near their antipodes, just twenty thousand kilometers away, over the seas. This means that in relation to communication of ideas by radio, the most remote countries are only about one tenth of a second apart. We all live on a tenth-of-a-second radio world. It does not seem likely that such a world can indefinitely support more than one system of weights and measures. It must only be a question of time, on a tenth second world, when only one system will supervene. Will this surviving system be the sixty-unit English system, the fifty-unit American system, or the three-unit metric system?

THE ANCIENT AND MODERN USE OF PLANT ARROW POISONS

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I. Ancient Record

How certain plants came to be used to poison the tips of arrows is not a question of general agreement. There are two main theories. The snake-bite theory assumes that the natives, upon witnessing the terrible effects of a snake bite, which was apparently accomplished by merely piercing the skin with a sharp point and injecting poison, came to smear the sharp arrow tip when hunting or in warfare. The latex-smear theory suggests that natives, upon being wounded, would naturally smear the juice or gummy exudate of some plant to arrest the blood flow and to heal. Some noted that the use of certain plants resulted in immediate poisoning and death. It is not too much to assume that sooner or later some native applied it to his arrow tip in order to carry the poison into the body of his game or to destroy his enemy in combat. Whatever the origin, the beginning of the use of arrow poisons is lost in antiquity.

A monographic treatment of plant arrow poisons would necessitate investigations in the fields of physiology, medicine, ethnology and even the study of the handicraft and decorative art of the indigenous tribes. Many startling and imaginative tales have been recorded in the literature. It is the purpose of this paper[2] to discuss the actual past and present employment of vegetable arrow poisons.

[2] Other papers now in preparation deal with the geographical distribution of the plant sources of arrow poisons and with the comparison of the physiological effect of the native arrow poisons with the pure drug.

The general application of poisoned arrows by ancient people is referred to in many instances by the early writers. The Biblical record in the Book of Job (VI–4) shows that the people of that period knew of arrow poisons. Homer indicates that the early Greeks were familiar with the practice. He has written in Odyssey I, page 260:

> He [Odysseus] came seeking the deadly drug, wherewith to anoint his bronze tipped arrows. He [*i.e.*, some unknown friend he had sought it from] did not give it to Odysseus—but my father gave him the drug, for he loved him exceedingly.

The nature of this poison is unknown but probably was of vegetable origin, as the word "unguere" (anoint) indicates. In fact, even the derivation of our term "toxic" is intimately associated with arrows and poison. To wit:

- Τόξον, a bow.
- Τόξα (the plural), often used for bow and arrows; the singular also sometimes has this use.
- Τα Τόξα, for arrows only in Sophocles and in Plato Laws.
- Τὸ Τοξικον (supply Φαρμακον), poison for smearing arrows, in the writings of Dioscorides, a physician of about 60 A. D.

Toxic means poisonous. A toxophilite is a lover of archery.

Virgil has written in Aeneid IX–772:

> There was no other man more skilled of hand than he
> In tincturing darts and arming steel with poison.

Horace infers in his ode to Aristius Fuscus[3] that African tribes along the

[3] Q. Horatii-Flacci, Opera, Lib. I, carm. XIX, Ode XXII.

northwest coast used arrow poisons. He has written:

> Integer vitae scelerisque purus
> Non eget Mauris jaculis, neque arcu,
> Nec venenatis gravida sagitta
> Fusce, pharetra.

Theophrastus[4] and Claudius[5] spoke of the Ethiopian arrow poisons. Although many of the natives in the regions of Africa which have been invaded by Europeans have given up arrows and arrow poisons in favor of firearms, there are, nevertheless, millions of people who still depend upon primitive weapons.

In Asia, as in Africa, reference to arrow poisons has been made by the earliest explorers. The most toxic arrow preparation of vegetable source in the Malay Archipelago is *Upas* or *Ipoh.* Rhumpius explains that both *Upas* and *Ipo* are to be translated as poison. *Pohon* is a tree. Hence, *Pohon-Upas* refers to a poisonous tree. *Radja* always signifies a chief or ruler or one who rejoices in power. The term, therefore, of *Upas-Radja* in early literature indicates that this plant arrow poison is a very powerful one.

Early literature dealing with South America is rich in records of vegetable arrow poisons, especially *Uirarery* or *Ourari,* which, in its modern spelling, is *Curare.* The first Spaniards who began the conquest of South America found plant arrow poisons in effective use. The early sixteenth century travelers, who explored the Magdalena River in northwestern South America, had great trouble in persuading their fellows to venture into the wilderness. The first sample of *Curare* was carried into Europe from British Guiana, in 1595, by Sir Walter Raleigh and was called *Ourari.*

Very few plant arrow poisons have been employed commonly in North America, although arrows and blowguns were the weapons. *Anemone* species of the Crowfoot family were used in northwestern Alaska. The stems of three or four plants were collected for the preparation of poisons in southwestern Oregon. The Erie Indians are reported[6] to have applied poisons to their arrows about 1635, but it is not known what plants, if any, were employed. Only a few tribes of Mexican Indians, especially the Seri in Sonora, indulged in this practice. They prepared the toxic paste principally from the latex of *Sebastiana Palmeri* Riley.

II. Modern Record

The modern use of plant arrow poisons is limited to the same geographical areas as in the past; namely, the greater part of Africa, northern India, southern and southeastern Asia, the Malay Archipelago, the Philippine Islands, the northern half of South America and by a few tribes in Japan, Alaska, Mexico and Central America. In many instances, natives have abandoned arrows for modern weapons but soak their bullets in their traditional arrow poison.

To-day, the principal plants used in Africa are various *Strychnos* species, *Strophanthus Kombe* Oliver, *S. hispidus* DC., *Calotropis procera* (Ait.) R.Br., *Acocanthera venenata* Don, *Adenium Boehmianum* Schinz., *Physostigma venenosum* Balfour, *Haemanthus toxicarius* L. (*Buphane toxicaria* (L.f.) Herb.), and *Erythrophloem guineense* Don. In 1905, Chambers[7] described the Fra Fra arrow poison in the Gold Coast Colony of Africa. This poison was responsible for the death, in about twenty minutes, of fifteen out of forty-five soldiers in the French Sudan. Leprince[8] investigated

[4] Theophrastii, Eresii, Opera, Part 1, Bk. IX, chap. XV.

[5] Claudianus, Cl., "De consulatu Stilichonis," Bk. 1, p. 351.

[6] Le Mercier, "The Jesuit Relat.," ed. Thwaites.

[7] Chambers, A., "*Journ. Roy. Army Med. Corps,* 5 (1905), 213–223.

[8] Leprince, M., "Étude pharmacognosique de l'*Adenium*" (1911).

the effect of arrow poison prepared from *Adenium*. Frolich[9] studied the effect of Muchi arrow poison. Lewin[10] discussed the preparation and effect of numerous African arrow poisons of vegetable origin.

In the Malay Archipelago, the chief arrow poison is *Ipoh,* which is prepared from a large tree, *Antiaris toxicaria* Leschen. The latex is evaporated down and smeared on the arrows. The effect[11] of this poison is fatal to man. Lewin[12] described the effect of Dyak poison on various animals. Plant arrow poisons, known as *Ipoh,* are prepared from several sources in some localities throughout the Malay peninsula. The plant customarily substituted for *Antiaris* is *Strychnos tieute* Leschen. The Negritos in the mountainous regions of the Philippine Islands still (1926) use arrow poisons prepared from *Lunasia amara* Blanco and *Lophopetalum toxicum* Loher.

Curare, the chief South American arrow poison, is obtained in most cases from the bindweed, *Strychnos toxifera* Schomb., *S. Gubleri* Planch. or *S. Castelnaei* Wedd. This poison is imported into the United States via Germany for use in our medical schools and physiological laboratories. Whereas, the African and Asiatic *Strychnos* arrow poison acts upon the spinal cord, curare centers its action upon the motor end-plates. Curare and other arrow poisons are used by some practically unknown tribes of Indians who inhabit but slightly explored areas. Further investigation of these regions will probably disclose interesting information both in regard to the racial differences in these people, already noted in captured individuals, and in the plant sources of their deadly preparations.

9 Frolich, A., *Journ. Physiol.*, 32 (1905), 319.

10 Lewin, L., "Die Pfeilgifte," (1923).

11 Roth, H. L., "The Natives of Sarawak and British North Borneo," 2, (1896).

12 Lewin, L., "Die Pfeilgifte," (1923).

Dr. W. L. Schurz[13] has called attention to a South American tree called "*assacú,*" which is feared by the natives because of the powerful astringent poison in its sap. The toxic flora of the Amazon includes poisons whose virtues are known only to the Indians. These toxins include the terrible *mata calado* or silent death, which is reputed to leave no trace in the system, as is apparently true of the Central American *camotillo;* and the capanço, about whose powers many tales are told.

The preparation of arrow poisons has always been carefully guarded as a secret to be religiously kept from the knowledge of others. The efficacy of these native plant poisons has been a source of terror to explorers. The most recent account[14] of the mystery and effect of Indian poisons is in connection with the death of Ogden T. McClurg, the publisher, who is believed to have been the victim of a Central American Maya poison. He died under peculiar circumstances and physicians were unable to assign any reason for his sudden death. Mr. McClurg was a member of the Mason-Spinden expedition to Yucatan. Twice he was ambushed by Maya Indians. The possibility of his having been merely scratched by a poisoned dart is now being discussed. This Maya poison is reported by R. J. Urruela, of San Salvador, to produce lethal results but without leaving detectable traces in the system. Senor Urruela calls this poison "*camotillo*" and says that it has been known to the Mayas for centuries. I will quote from his report regarding this poison as follows:

> I knew camotillo by legend. Now I know it by the terrible experience of fact. Three deaths of prominent political men in Latin America have given me the absolute certainty of its menacing existence and its lethal effects.

13 Schurz, W. L., *National Geog. Mag.*, XLIX, No. 4 (April, 1926), 455.

14 White, A. R., N. Y. *Evening World*, April 27, 1926.

. . . I determined to get definite information about camotillo. I left for Copan, Honduras, where the ruins of the Maya temples are located. . . . Finally I met a Spanish priest who had charge of one of the many churches in Copan. . . . He told me that the Maya tribes are the only ones that possess the secret and they live far in the interior, in Atlantida, where there are no roads and but one white man is allowed to enter their domains. He is the priest in charge of their church. If you can meet him, he will give you all the information that is to be had about camotillo. . . . I met Padre Nicolas, a Spaniard.

Padre Nicolas spoke as follows: "I came to this tribe, called the Chancatales, which means 'the never defeated,' by order of my superior, the Bishop of Copan. I am the only white man allowed in their city, which is many miles inland. Sentinels are scattered all over the woods. Every stranger who approaches is immediately signaled. If he refuses to turn back he will never be seen by his people again. The Chancatales clan is ruled by a group of brujos (wizards) who have inherited the secrets of their forefathers. The brujos are the only ones who understand the preparation of camotillo. The poison is obtained from a vegetable bulb, in appearance very similar to a potato. It grows wild and cannot be found except by one who knows. The bulb is dried and passes through a series of manipulations until finally it is ground to powder. In the same length of time taken to dry and grind the bulb, the preparation will work its effect. A camotillo dried and ground in eleven moons will take eleven moons to kill. They can predict the occurrence of death with uncanny accuracy."

How much of this case of Maya poison is fact and fiction is difficult to ascertain. It is evident, however, that the prevalent use of plant poisons on arrows, darts and in other ways with criminal intent demands the attention of the tropical physician, traveler and explorer. It is significant that the natives have selected by some means, probably by the disastrous trial and error process, the most toxic plants in their respective localities as the sources of their poisons. The arrow poison plants are, therefore, indicative of the local toxic flora. There is much to be accomplished by research on the plant sources, uses and antidotes for vegetable arrow poisons.

WHAT IS AN INSTITUTION?

By Professor EDWARD CARY HAYES
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THE interesting article of Professor Ezra Bowen in the April SCIENTIFIC MONTHLY calls for a supplement.

He truly says that private possession exists in its most absolute form in primitive society, but he confuses the mere fact of physical possession with an *institution* of private property. He gives no hint as to what an institution really is. And the facts he adduces have little or no bearing on the question he is arguing: what were the earliest forms of the institution of property? Mere physical possession he calls the "oldest and most uncompromising of social institutions." In reality, however, mere possession by the strong individual does not imply the existence of an institution of private property.

If (as he says) in time of drought the one remaining water-hole is monopolized by one enormous hippopotamus, that does not indicate that there is an institution of private property, neither does the dog's monopoly of his bone, the child's monopoly of his drum or the savage's monopoly of a well-shaped club that he has found or made or taken from a fallen foe. The institution of private property does not begin till society decides to protect the possessor in his possession and decides also on what terms and within what limits society will so protect him. The institution of private property defines and limits as well as protects the right of possession. Mere possession of the primitive sort is based on might and has nothing to do with right nor with any institution.

A relatively primitive institution regarding private property is to be seen in the rules by which an Australian hunter divides the kangaroo which he has slain among his relatives—rules which require him to make this division as well as protect him in his own share.

True, as Professor Bowen says, we no longer bury a dead man's property with him for we no longer fear his ghost. We have substituted the institution of inheritance, a purely social convention grounded on a judgment of social expediency and limited, if society so wills, and to any degree which society finds expedient, by the taxation of inheritances, by primogeniture or even by escheat. Taxes, eminent domain and police power are social institutions, but mere crude and primitive possession by the strong is not a social institution.

There have been scholars who insisted that only might makes right and that anything is right which can be enforced. They were utterly wrong when they meant that the assertion of interest or impulse by an individual against other individuals or by a class or group against other classes or groups created a right by virtue of the fact that the claim was asserted and enforced. But they would not have been wrong if they had said and meant that what the judgment and sentiment of a society enforces upon its own members is in that society right. "Right" as well as "rights" are social concepts, and as Professor Sumner says, "society can make anything right" in that society.

These two statements include the reasons why problems of ethics are matter-of-fact problems and why the study of ethics is no more the affair of meta-

physical speculation than the problems of agriculture or of bridge building. The history of moral codes is altogether a part of the story of social evolution, and the criticism of moral codes is altogether a matter of fact inquiry. We still give to one who is trained in chemistry or physics the degree of doctor of philosophy. This is reminiscent of the period in which all sciences were only emerging from the metaphysical stage, as now at length ethics has begun to emerge. That ethics has thus begun to emerge from the metaphysical stage and to be treated as a matter of social evolution and practical social inquiry is perhaps the most important part of what sociology is bringing to pass.

The institutional definition of property rights is based on the perceptions (1) that private possession rewards and elicits productive effort, (2) secures orderly and efficient administration of material resources and (3) is just. By "just" we mean that it is an arrangement consonant with a balanced regard for all the interests affected. The institution of private property as distinguished from the mere fact of possession is an effort on the part of society so to define, limit and protect possession as to secure so far as practicable the three results just specified: reward and promotion of productive effort, orderly and efficient administration of material resources and justice. Any limitation of the rights of private possession or redefinition of them which is required by these three criteria is not only justified, but demanded.

An institution is a mode of social activity. It is one of those socially evolved and socially prevalent activities which are included in the "culture" of a people. Whether one is a behaviorist or not, from any scientific point of view having an idea or having a feeling is an activity as truly as driving a nail. Ideas and feelings are elements in all distinctively human activity, whether the activity completes itself in overt muscular movement or not. Any social activity that can be called an institution is essentially a set of ideas and feelings that prevail in a society and that go over into overt conduct when occasion arises, together with a prevalent habitual disposition to these activities. Fundamentally institutions are states of mind, *i.e.*, ideas and feelings are their essence. An institution like trial by jury, when the activity becomes overt, supplies itself with a personnel, such as judges, lawyers, jurors and bailiffs, and with a material equipment, such as court house, bench, bar and jury-box, but the building may be burned, the personnel beheaded and the surviving members of the society may migrate to a new continent, yet they will carry their institutions with them if they retain their habitual states of mind.

An institution is a mode of social behavior and one which in contrast with mere fashion and custom includes an element of rationality, a practical judgment, approving both the ends sought and the methods employed in the activity.

Human culture has three stages. In the first it is molded by biological necessity. Group practices are defined by the requirements of group survival. In the second stage, death being somewhat held at bay, there is room for many nonadvantageous vagaries. In the third stage, rational acceptance in the light of experience converts useful customs into institutions and invents new institutional forms. And ripened institutions, economic, domestic, political, etc., have striking resemblances to the group customs which at an earlier stage were enforced by biological necessity.

TWO ENTOMOLOGISTS OF THE EIGHTEENTH CENTURY—ELEAZAR ALBIN AND MOSES HARRIS

By HARRY B. WEISS

NEW BRUNSWICK, N. J.

Eleazar Albin

"Now it is the general complaint of the taverns, the coffee-houses, the shop-keepers and others that their customers are afraid when it is dark to come to their houses and shops for fear that their hats and wigs should be snitched from their heads or their swords taken from their sides, or that they may be blinded, knocked down, cut or stabbed; nay the coaches cannot secure them, but they are likewise cut and robbed in the public streets, &c. By which means the traffic of the City is much interrupted." So said the city marshal of London in 1718. On the other hand, there was the small but lively world of fashion, politics, literature and art with its phosphorescent society of statesmen, politicians, authors, wits, rakes and dandies.

This is the London that Eleazar Albin knew, a London in which the forces of disorder were strong and a London whose *beau monde* enabled him to make a living. Of German origin, his family name having been Weiss, Albin taught drawing and painting in water-colors. This led to an interest in flowers and insects, especially the latter, which he painted at first simply for his own pleasure. Later he became acquainted with a collector, a Mr. Dandridge, who employed him in painting caterpillars and who also recommended him to Mrs. Howe, widow of Dr. George Howe, of the College of Physicians of London, who died in 1710. Mrs. Howe's interest being in the Lepidoptera, Albin painted a large number of butterflies and caterpillars for her. He also did several things relating to natural history for Sir Hans Sloane, erroneously considered by many as having been the sole founder of the British Museum, when, as a matter of fact, there had been, long before Sloane's time, sedulous and frequent efforts to arouse the government to the importance of public museums. Sloane's will, however, did provide the opportunity for the foundation.

Following his work for Sloane, Albin was introduced to Her Grace Mary, Duchess Dowager of Beaufort, who employed him in a similar manner and advised him to embark on his "Natural History of English Insects," giving him such substantial aid as securing subscriptions from several persons of the "first quality." While she lived, Albin made rapid progress on his book, but after her death the subscriptions dropped off and the work was delayed. Albin had a "great" family and needed the subscriptions in order to complete the book. About 170 subscribers were finally secured and the work appeared in 1720, entitled "A Natural History of English Insects, illustrated with a Hundred Copper Plates, Curiously Engraved from the Life; And (for those who desire it) Exactly Coloured by the Author."

Among the subscribers were members of the nobility, an apothecary, a stationer, a music teacher, a chemist, a surgeon, the treasurer of the East-India Company, a gardener, a lawyer, a doctor, a merchant, a professor and a gentleman. Some of the subscribers were

Lord Bruce, the Earl of Cardigan, the Duke of Devonshire, who was the Lord Steward of the King's Court, the Earl of Strafford, the Countess of Salisbury, Mrs. Howard the Countess of Suffolk, society and Court favorite, Lady Stuart, etc.

The book for the most part deals with the Lepidoptera, although a few insects of other orders are included. Each plate is dedicated to a subscriber and accompanied by a page of text. The plates illustrate the adult insects, larvae, pupae and food plants, while the text describes the colors of the species, eggs, early stages, food plants, parasites, remedies for the injurious insects and miscellaneous observations, all rather briefly. In the introduction Albin says that during all his observations he did not meet with one instance that gave him reason to doubt that insects in general were produced by parents of the same species and remarks with some naïveté that in this he is confirmed by Redi's book, "Experiments on the Generation of Insects," which, incidentally, appeared in 1668. A second edition of Albin's book "with Notes and Observations" by W. Derham appeared in London, 1724, a third edition in Latin in 1731 and a fourth in 1749.

His next book venture was "A Natural History of Birds," in three volumes, 1731, 1734 and 1738, accompanied by a total of 306 copper plates colored by himself and his daughter Elizabeth, whom he had taught to draw and paint. A second edition was printed in 1738–1740, and a translation, supplemented with notes and remarks by W. Derham, was published in French at Hague in 1750.

William Derham was a minister who was interested in natural history and mechanics. He wrote a number of papers on various subjects, including the migration of birds, the weather, the habits of the deathwatch and of wasps, etc., and had a large collection of birds and insects. He also published religious works of his own and edited the correspondence of John Ray.

Albin solicits, in his "Natural History of Birds," presents of curious birds and advises the prospective donors that the specimens should be sent to him in the comfortable vicinage of the "Dog and Duck." To Sir Robert Abdy, who helped him in the collection of birds and on various occasions, the first two volumes are dedicated; the third volume to Richard Mead, physician in ordinary to George II, a man who had a high reputation as a practitioner and writer on medical subjects and who devoted much study to natural history and antiquarianism.

Each plate of Albin's bird book is accompanied by a page of text, but the plates are not dedicated to subscribers, at least not in the second edition. His plates are said to be greatly inferior to those in Catesby's "Natural History of Carolina," and one critic stated that Albin must have been ignorant of ornithology.

Albin's next book was "A Natural History of Spiders and other Curious Insects, Illustrated with Fifty-three Copper Plates Engraved by the Best Hands," which was published in London in 1736. In his statement "To the Reader," Albin quotes from the "Spectator" No. 121, published some twenty-five years before, in which Addison expresses the wish that some one would "take each his particular species and give a distinct account of the frame and texture of its parts—especially those that would distinguish it from other animals," believing that such studies would be a service to mankind. Albin somewhat pompously says that on the wish of Addison he built his book on spiders, describing two hundred different kinds and giving the results of his own observations. The work is dedicated to

Dr. Mead and contains the names of some sixty-four subscribers, including those of eight booksellers. Among the subscribers are the Empress of Russia, the Countess of Suffolk, who numbered among her friends many of the men of letters of her time, Pope, Gay, Swift, Arbuthnot, etc., and who was the mistress of the Prince of Wales, afterwards George II, Sir Hans Sloane, who subscribed to all Albin's works, Lady Mary Booth, Lady Mary Gore and many other members of the court circle around the periphery of which Albin hovered.

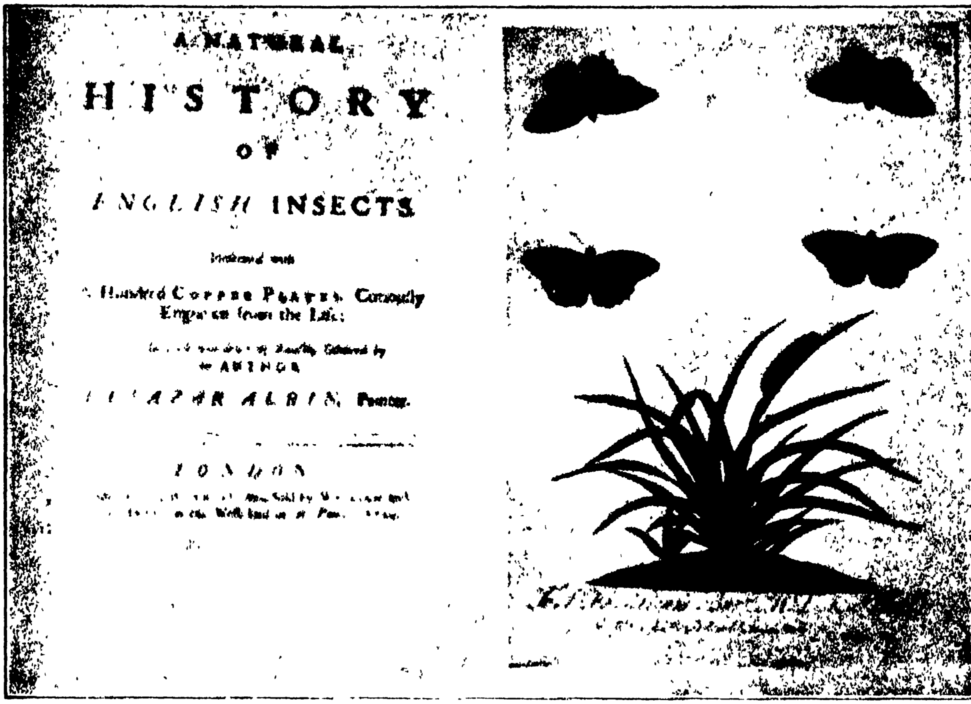
To Albin's treatise on spiders are appended three short papers, one entitled "Of the Tarantula" by Dr. Mead, and the remaining two, "Microscopical Observations on the Carter Spider, and Jumping Spider," and "Observations on the Flea, and Louse," both by "the late ingenious Dr. Hooke, F.R.S." Some of the plates are signed by Albin as artist, and Thomas Martyn, who made Albin's work the basis of a more comprehensive volume in 1793, praised the drawings for their correctness but disapproved of the text as being disconnected and without order, although at times entertaining and instructive. The frontispiece consists of a portrait of Albin on horseback, said to be by J. Scotin, surrounded by pictures of spiders, mites and scorpions, although the plate, dated 1737, is signed by Albin as artist and by Scotin as engraver. Jean Baptiste Scotin flourished in Paris during the first half of the eighteenth century and engraved after H. Rigaud, Boucher, Watteau, Lancret, Pater and other French painters. In the illustration Albin, on his white horse and resplendent in a green coat and black hat, outshines the surrounding arthropods.

In 1737 his "Natural History of English Songbirds," with colored plates, appeared, later editions being printed in 1747, 1759, 1779, London, and an Edinburgh edition in 1776. His last work, entitled "The History of Esculent Fish," with plates drawn and engraved by E. Albin and with an essay on the breeding of fish and construction of fish ponds by Roger North, a lawyer and historian who died in 1734, was not published until 1794. It is illustrated by some eighteen plates signed variously by E. Albin, Elizabeth Albin, Eleazar Albin, Eliza Albin, Eliz. Albin and Fortin Albin, and dated 1735, 1736, 1739, 1740, etc. Fuseli, the designer and painter, who was also interested in entomology, found in a catalogue under Albin the three names Eleazar, Elizabeth and Fortin, and speculated upon the relationship of the first and last two. Elizabeth was Eleazar's daughter, as noted heretofore, and although nothing is said in the text of Albin's books, the fact that three of the fish plates are signed by Fortin and accompanied by plates by both Elizabeth and Eleazar seems to indicate a relationship, possibly that of father and son.

Nothing is known of the dates of Albin's birth and death. He flourished from about 1713 to 1759, and according to Bryan's "Dictionary of Painters and Engravers," there is a "Rich Man and Lazarus," by him in the Gallery at Cassel. His portrait indicates that he was a rather well-built man, probably somewhat swanky in view of the "quality" of his patrons and subscribers, and withal perhaps rather lacking in a sense of humor so far as he himself was concerned, as evinced by his equestrian representation, his green coat and his black hat. Nevertheless, Albin put something of himself in each of his books and there is a certain friendliness about them which is non-existent in the cold, impersonal and standardized manuals of to-day.

Moses Harris

The great fire of London broke out on September 2, 1666, and Evelyn, as recorded in his "Diary" on September 3, "saw the whole south part of the city

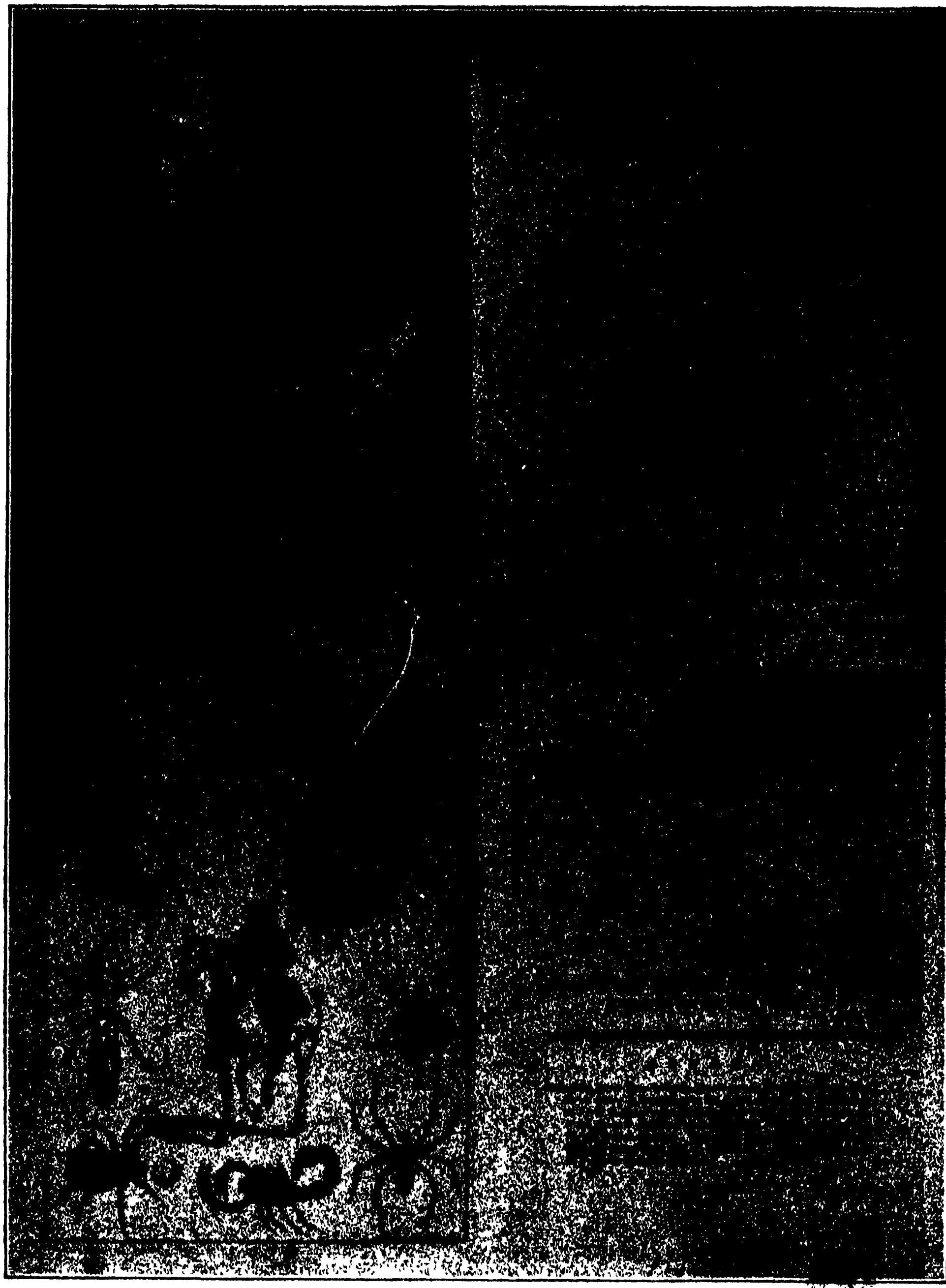


TITLE PAGE OF ALBIN'S "NATURAL HISTORY OF ENGLISH INSECTS," 1720, AND PLATE 53 DEDICATED TO SIR HANS SLOANE.

burning, from Cheapside to the Thames, and all along Cornhill (for it likewise kindled back against the wind as well as forward), Tower Street, Fenchurch Street, Gracechurch Street, and so along to Bayard's Castle." Under the entry dated September 7, at which time the fire was almost out, he speaks of the ruin and desolation and of going on foot through the various streets or what was left of them and "thence through Cornhill, with extraordinary difficulty clambering over heaps of yet smoking rubbish, and frequently mistaking" his location.

In this fire, in the Cornhill section, perished the collection and books of the Society of Aurelians to which Moses Harris's uncle of the same name later belonged. The society held its meetings in the Swan Tavern in Change Alley, and the members who were sitting at the time "had to escape suddenly, many leaving their hats and canes." However, it does not seem likely that even entomologists would delay their departure until the fire was so close upon them. The Swan Tavern may have been the one said to have been rebuilt as the Swan and Rummer after the fire and often frequented in the early part of the eighteenth century by Gay, Swift, Arbuthnot and other brilliant wits of that age and from which they would be chaired home after a sparkling evening.

Moses received his first instructions in collecting insects at about the age of twelve, from his uncle, who must have been close to ninety at the time, if rather uncertain dates are accepted. For more than twenty years he collected insects and drew, engraved and colored them, chiefly moths and butterflies, being an acute observer and a good entomolog-



UPPER: FRONTISPIECE AND TITLE PAGE OF THE "AURELIAN," 1778, BY MOSES HARRIS. LOWER: FRONTISPIECE AND TITLE PAGE OF ALBIN'S "NATURAL HISTORY OF SPIDERS AND OTHER CURIOS INSECTS," 1736.

ical artist and engraver on copper. This industry bore fruit in the shape of his book entitled "The Aurelian or Natural History of English Insects; namely, Moths and Butterflies, together with the Plants on which they Feed," which he published in London in 1766. The title page also bears the statement that the work is "A faithful Account of their respective Changes; their usual Haunts when in the winged State; and their standard Names, as given and established by the worthy and ingenious Society of Aurelians" of which Harris was secretary.

The forty-five plates, for the most part dedicated to members of the aristocracy, were drawn, engraved and colored by the author. Harris states in the introduction that he had many pleasant collecting trips during the pursuit of his work. A large part of the prelude is concerned with the general life-history of the Lepidoptera, collecting nets and how to use them, boxes, setting boards, etc., while the text proper deals with descriptions and markings of adults and notes on life-histories and food plants. The frontispiece consists of a sylvan scene, including a portrait of the author sitting on the bank of a stream, a collecting net over his knees, a chip box of butterflies and other insects in his left hand and his right hand pointing to a small figure, of himself presumably, using the net on the opposite side of the stream. The plate is signed by Harris. The title page of the copy of this work in the American Museum of Natural History library bears the following statement, "Printed for the author, London 1766, and with great additions, for J. Robson, New Bond Street MDCCLXXVIII," and the text is in both English and French, parallel columns. Harris also drew, etched and colored most of the plates in the three volumes of Dru Drury's "Illustrations of Natural History" published 1770–82 and contributed some unimportant drawings to the Catalogue of Andrew Peter Dupont's Collection of Natural Curiosities.

Harris's "Natural History of English Insects" was reissued in 1778, 1794 and in 1840 under the editorship of J. O. Westwood. Hagen was of the opinion that the "Aurelian" originally appeared in numbers. After the first edition was printed, Harris published an appendix which was sold separately, according to the announcement in his "Pocket Companion" of 1775. In 1827 there appeared in the "Retrospective Review" (London) an index of modern generic names for Harris's "Aurelian."

The first attempt to classify Lepidoptera according to the venation of the wings was made by Harris in "An Essay precedeing (sic) a Supplement to the Aurelian wherein are considered the Tendons and Membranes of the wings of Butterflies, &c," published by the author in 1767 (London). In this essay attention was paid also to the differences in shape in the scales and of the hooks. In this work the author's name is followed by the words "Miniature-Printer."

Harris's next book was "The English Lepidoptera, or the Aurelian's Pocket Companion, containing a Catalogue of upward of four hundred Moths and Butterflies, &c," printed in London, 1775. This was followed in 1776 by "An Exposition of English Insects," in English and French, which dealt mainly with the Neuroptera, Diptera and Hymenoptera. In the preface Harris states that although it is customary for authors to apologize for those who study natural history, he is at a loss to know "to whom such apology should be made," as those who object "are generally men of small capacity and low wit, having a mean conception of things in general." Copies were issued apparently with new title pages dated

1781, 1782, 1783, 1786. Hagen stated that the text in the copies dated 1776, 1781 and 1782 was the same throughout, but that at least thirteen of the plates had been re-engraved once or even twice. He believed that the work originally appeared in numbers and increasing sales made it necessary to re-engrave some of the plates.

Harris's last publication was the "Natural History of Colours" edited by Thomas Martyn, London, 1811, and dedicated to Sir Joshua Reynolds. In the preface, Martyn speaks of Harris as having been dead nearly thirty years, which would make the year of his demise 1781, or thereabouts, but Graves's "Dictionary of Artists" records that a frame of English insects was exhibited by Harris at the Royal Academy in 1785.

Harris is thought to have been born about 1731 or 1734. Little is known of his life, except that he flourished apparently between 1766 and 1785 and wrote and illustrated the books mentioned. From a letter dated April 5, 1770, that was written by Dru Drury to Harris, it appears that Harris was then living some distance from London, was married and had a son. If he did not actually live in London at some time, his books were published there and he probably made many trips to the city. London in many ways did not improve greatly from Albin's to Harris's time, if the statements of various writers can be relied upon. Walpole wrote in 1750, "You will hear little news from England but of robberies, the numbers of disbanded soldiers and sailors have taken to the road or rather to the street." Shebbeare, writing about the middle of the century, said, "In London amongst the lower classes all is anarchy, drunkenness and thievery, in the country, good order, sobriety, and honesty, unless in manufacturing towns, where the resemblance to London is more conspicuous." Grosley, who visited London in 1765, said that "porters, sailors, chairmen and the day labourers who work in the streets are as insolent a rabble as can be met with in countries without law or police" but that citizens and shopkeepers, journeymen and artisans in skilled trades were obliging.

During the eighteenth century England was at war for about half the time, and the changes from war to peace and peace to war were accompanied by disturbing economic conditions. During war, trade was good, but peace brought dullness, inactivity and suffering, filling the jails and debtors' prisons. In addition, work in many London trades was irregular; the tailors, for example, were said in 1747 to be "as numerous as locusts, out of business three or four months of the year, and generally as poor as rats." It would be interesting to know how entomologists, engravers and artists fared with changing business conditions and the varying fortunes of their patrons. Harris's circumstances were thought to have been fairly comfortable, although in the introduction to the "Aurelian" he mentions losses due to the "unsteady and fallacious Behaviour of a Person too nearly connected in my Concerns."

If his portrait is not too flattering, he was of rather slender build, comely and altogether quite prepossessing. He must have been intensely in love with his work, both as an artist and engraver and as an entomologist, for his books leave one with the impression that in them he endeavored to express himself both artistically and entomologically.

THE PROGRESS OF SCIENCE

By Dr. E. E. Slosson
Director of Science Service, Inc., Washington, D. C.

REFRIGERATION BY A FLAME

There are a dozen different household refrigerators now on the market and each is better than all the others. I know that because it has been proved to me in person by representatives of the various manufacturers in the two weeks since I carelessly allowed it to be known that I was thinking of buying an iceless icebox as a surprise to my wife. So many eloquent advocates of family coolers have visited me that I get cold shivers whenever I see a stranger at my door. When the methyl chloride man gets me convinced that he has the best refrigerant, one of the sulfur dioxide agents comes in and overturns all his arguments, and the next caller converts me to iso-butane.

And in the midst of this mental confusion I open the foreign mail and find in *Engineering* and *La Nature* new and original refrigerators have been invented, one cooled by a gas flame and the other by steam.

Both are based upon the familiar principle that the rapid evaporation of a liquid into a gas absorbs heat from its surroundings and accordingly cools them. One uses ammonia for this purpose and the other simply water.

The former is the invention of two Swedes, Baltzat de Platen and Carl G. Menters, of the Royal University of Technology at Stockholm. In employing ammonia as the cooling gas it is like most refrigerating plants, but it has no condensing pump as is customary. In fact it has no machinery, no moving parts of any kind. It consists simply of a series of four tight metal containers, connected by tubes, the whole charged with ammonia, water and hydrogen under a pressure 180 pounds per square inch and hermetically sealed. The first vessel is a generator in which ammonia gas is liberated from the liquor by heating with a gas jet or electric coil. The ammonia gas then passes into a rectifier and condenser where it is cooled by running water and reduced to the liquid state. This liquefied ammonia goes next into the evaporator where it is relieved of its pressure and becomes gaseous again. The evaporator is situated inside the refrigerator-box, which is continually cooled by the expansion of the liquid ammonia into ammonia gas. This finally flows into the absorber where it dissolves in water and runs back to the generator to start upon its rounds once more. The evaporation of the ammonia is due to its fall in pressure from 180 pounds per square inch in the generator to a partial pressure of 30 pounds per square inch in the evaporator. This is accomplished by an ingenious application of a law discovered by John Dalton over a century ago, that the total pressure of a mixture of gases is equal to the sum of the pressures that each gas in the same space would exert if the other gas

DR. ALBERT A. MICHELSON

PROFESSOR OF PHYSICS IN THE UNIVERSITY OF CHICAGO, PRESENTING AT THE PHILADELPHIA MEETING OF THE NATIONAL ACADEMY OF SCIENCES HIS MEASUREMENTS DETERMINING THE VELOCITY OF LIGHT. DR. MICHELSON IS PRESIDENT OF THE ACADEMY.

were absent. Now the evaporator is filled with an atmosphere of hydrogen gas which gives a partial pressure of 150 pounds. When the ammonia which has been liquefied under a pressure of 180 pounds comes into the chamber where the pressure due to hydrogen is only 150 pounds, it evaporates at a rate sufficient to make up the difference between the two, 30 pounds, and this causes the cooling. The hydrogen is kept from getting into the other part of the apparatus by a curved tube filled with water through which ammonia can pass but not hydrogen.

The manufacturers claim that the family-size refrigerator will absorb heat to the amount of 320 British Thermal Units per hour and may be run for a day by currents of 3 kilowatt hours of electricity and about 120 gallons of water. If electricity is not available a gas flame may be used for heating the generator. The apparatus is not at present automatically started and stopped but is so arranged that a single handle turns on the gas and water supply together. So the cook can bake her cake by a gas fire and then switch it over to freeze her ice-cream.

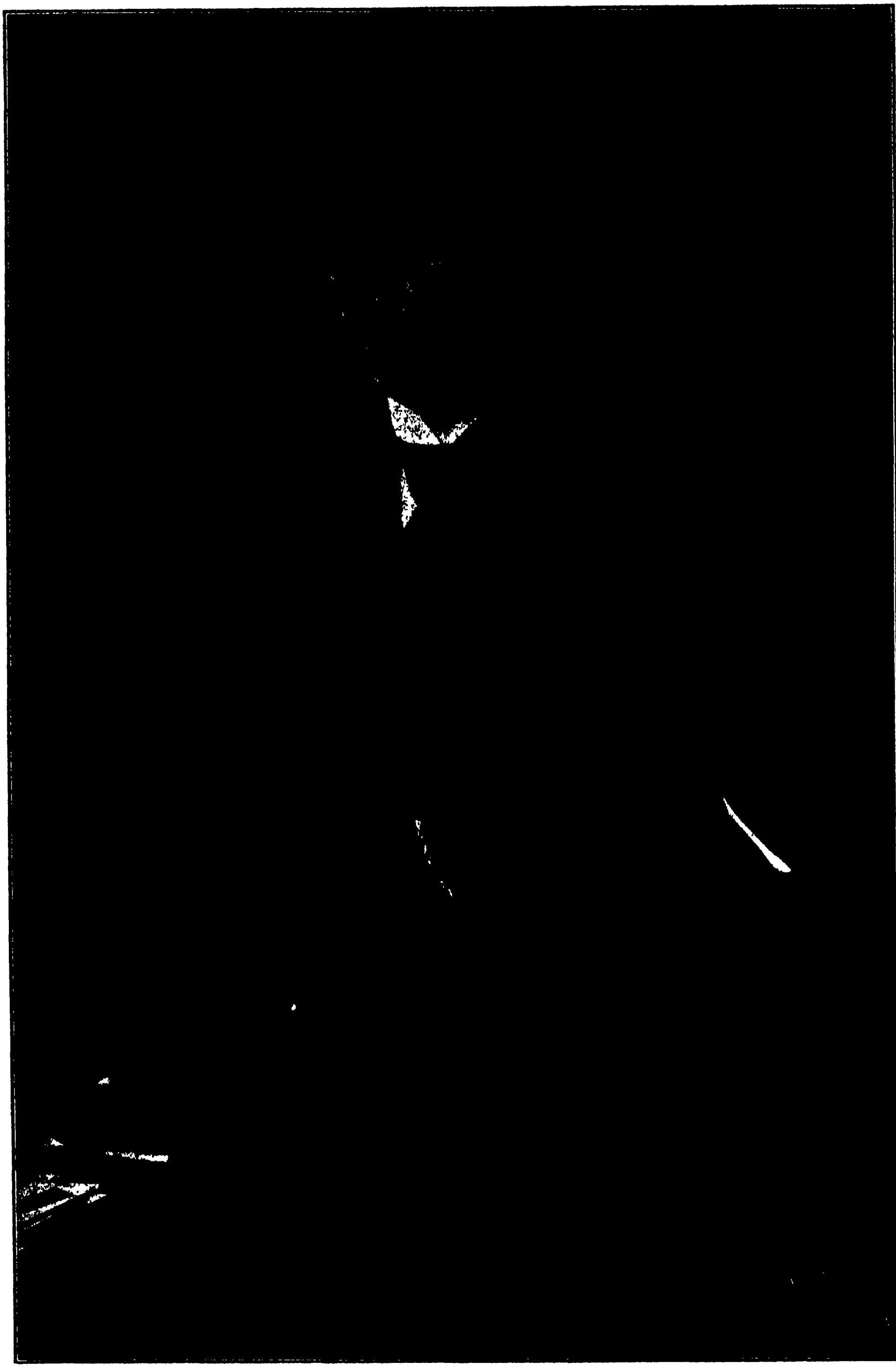
The French machine invented by R. Follain is interesting because water is the only means employed. This is doubly advantageous since water is everywhere cheap and absorbs a larger quantity of heat on evaporation than any other substance known. In this apparatus the evaporation is hastened and therefore the cooling effect is intensified by creating a vacuum above the surface of the water in an airtight tank by the injection of a steam jet in a constricted tube. The water vapor and steam are condensed in an adjoining chamber by a spray of cold water. Several such systems can be arranged in series in order to secure the desired reduction of temperature. Such a machine will cool 1,250 gallons of water from 77 degrees to 37 degrees Fahrenheit. To accomplish this requires about 790 pounds of water used as steam for the injector and 22 tons of water for cooling.

But there is not room enough in our pantry for all this. I think I will postpone my purchase until one of the machines drives all its rivals out of the market. But the danger of such a policy of watchful waiting is that the law of the survival of the fittest does not always hold in the commercial struggle for existence. The machine which comes out supreme in sales may be the poorest and cheapest to make, because it has the largest surplus to spend on advertisements and agents.

THE CATALYSIS OF COAL

In the old days before the war men did not know anything better to do with coal than to burn it. Now they are beginning to find out that it may be put to better purposes as raw material for making more valuable commodities.

In those days too when men wanted to get more gasoline than petroleum contained, they knew no other way to get it than to smash up the big molecules into little ones, to break down the heavy oils to make light oils. This "cracking" process was regarded as a great achievement in its day and brought fame and fortune to its inventor; quite rightly, since we could be running few automobiles without it. But the world is passing into another era now, the age of synthesis, when the chemist will build up instead of breaking down. Starting with the commonest and cheapest materials, air, water and coal, the chemist



DR. FRIEDRICH VON MÜLLER

THE DISTINGUISHED PHYSIOLOGIST AND PATHOLOGIST OF THE UNIVERSITY OF MUNICH, WHO HAS BEEN LECTURING IN THE UNITED STATES.

can construct at will all sorts of valuable compounds for which we formerly had to rely upon nature.

The veteran French chemist Professor Paul Sabatier, of Toulouse, recently on a visit to America, opened the door to this new era with the key called "catalysis." Shortly before the century closed he found that hydrogen gas could be made to unite with carbon monoxide gas in the presence of finely divided nickel and produce methane, well known as natural gas. Now these two constituents, hydrogen and carbon monoxide, are easily made by passing steam over red hot coal, the "water gas" process. Many other metals and compounds have since been found to act like nickel as a catalyst, that is, they speed up a process by their presence without being used up or appearing among the products.

This principle has of late been applied with remarkable results by a countryman of Sabatier, General Georges Patart, and still more extensively in Germany by Professor Franz Fischer, director of the Institute of Coal Research at Muelheim Ruhr, and Dr. Friedrich Bergius, of Heidelberg. All these three European leaders in catalytic research went to Pittsburgh to attend the International Conference on Coal held at the Carnegie Institute of Technology from November 15 to 19, and what they told of the application of catalysis to industry was new to many of our people, for in this field America is far behind Germany and France.

For instance, we have been making methanol by the old-fashioned method of distilling wood, but now the Badische Chemical Company makes ten to twenty tons of it a day from water gas at a cost of only 20 cents a gallon. Methanol, formerly known as "wood alcohol," has long been employed in all countries as a denaturant for industrial alcohol, and has caused many cases of blindness in Germany and America by being used for whiskey by those who were already so blind as not to tell one alcohol from another. Various other alcohols, such as butyl alcohol, made in America by fermenting corn and used for automobile lacquers, are made in Germany from water gas. The waste gases that in some sections of the United States are still allowed to escape from coke ovens unused are at the mines of Bethune, France, cooled and condensed and utilized for making methane, benzene, ethyl alcohol and ammonia.

Owing to the catalytic process for synthetic ammonia invented by Fritz Haber, Germany is now exporting fertilizer instead of importing it as before the war. About 425,000 tons of free nitrogen from the air is now fixed for fertilizers by catalysis every year, and this takes the place of 2,700,000 tons of Chilean nitrate. But Muscle Shoals still stands idle.

Benzene, which can be made from coal in various ways, is the mother substance of the aromatic family of chemical compounds, a family of over a hundred thousand and rapidly growing. Among these are the aniline dyes and drugs that have made the world brighter and safer in our generation. One of these synthetic products, carbolic acid, is familiarly used as an antiseptic and is nearly as useful but much less familiar as one of the two components of bakelite. The other component, formaldehyde, is also an antiseptic and also made artificially.

The chief stimulus to such investigations in Europe is the search for home-made motor fuel. We Americans are not interested in this question now but some day we shall be, and meantime it is interesting to watch the chemists over the water trying to see how many different things they can make out of common coal, like children playing with the Chinese tangram.

DR. WILLIAM D. COOLIDGE.

THE NEW COOLIDGE CATHODE RAY TUBE

A VACUUM tube which produces as many electrons per second as a ton of radium—and there is only a pound of that rare substance in the world—was announced by Dr. W. D. Coolidge, of the research laboratory of the General Electric Company, at a meeting of the Franklin Institute of Philadelphia, on the occasion of the award to him of the Howard N. Potts gold medal of the institute for his outstanding work in the development of X-ray tubes.

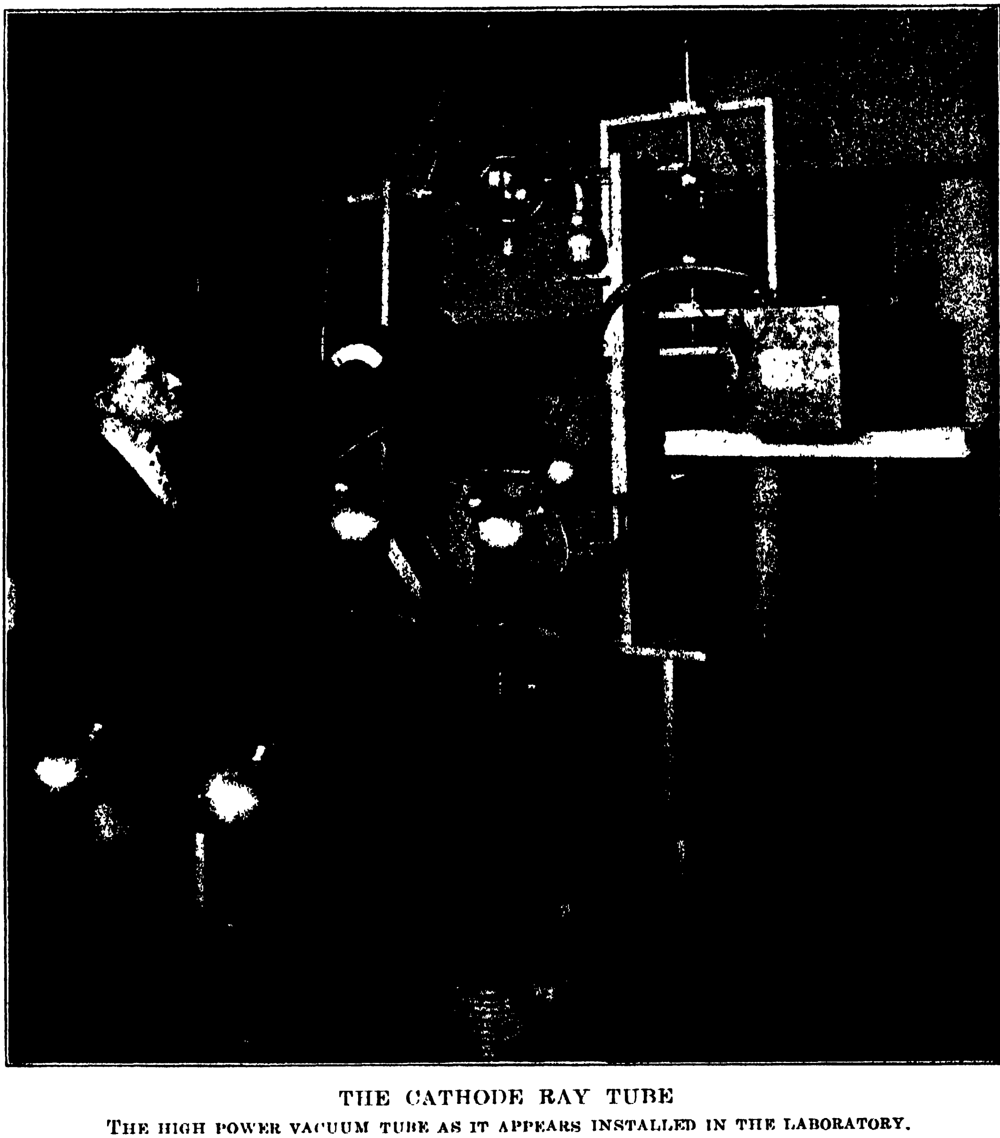
Radium is constantly disintegrating, and in so doing is bombarding electrons —infinitely small particles of matter or electricity—into space at very high velocities. The rate at which radium disintegrates is beyond human control; nothing that man can do seems to affect the rate at which the element breaks down. The cathode ray tube likewise bombards high speed electrons into space, but at a rate that can be controlled by man, and in quantities far greater than by all the radium in the world. The electrons given off by radium are of higher average velocity than those so far produced with the cathode ray tube, but otherwise the two are alike.

So much more concentrated are the rays from the tube that many startling experiments have been conducted with the new device. Crystals of the mineral calcite apparently become red hot coals when exposed for a moment to the rays, but they are glowing with cold light; ordinary salt is turned brown, and considerable time elapses before it again becomes the colorless substance it usually is; bacteria and small flies are almost instantly killed by exposure to the rays; ordinarily colorless acetylene gas is transformed into a yellow solid which can not be dissolved; and a rabbit's gray hair has been destroyed, to be replaced later by a profuse growth of longer, snow-white hair.

Cathode rays have been known to some extent for many years. At first, however, they were known only within vacuum tubes, but about thirty years ago a European scientist, Lenard, succeeded in making the electrons pass through a tiny piece of extremely thin aluminum foil cemented to the glass wall of the tube. Improvements have been numerous since then, but with previous tubes the metal "windows" were much smaller and the operating voltages much lower than with the new tube.

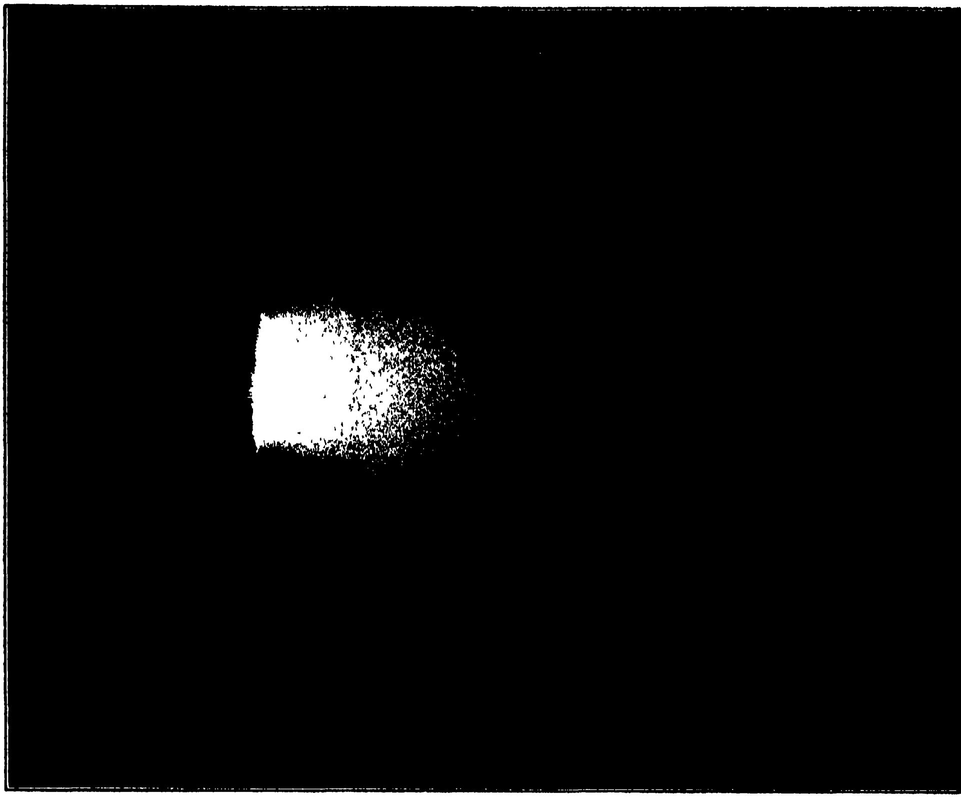
Several unusual features have been incorporated in the new tube. There is a "window" three inches in diameter, of nickel foil, the thickness of which is measured in thousandths of an inch and which is capable of withstanding a total atmospheric pressure of more than 100 pounds. A heated tungsten filament, originally used by Dr. Coolidge in the X-ray tube and now known to all as an essential part of radio tubes, furnishes the supply of electrons. The glass tube has been shielded with a copper tube so that the stream of electrons can not strike the glass and cause punctures, thereby permitting operation of the tube at voltages far higher than any previously attained, and the tube is also the first which it has been possible to seal off from an evacuating system; the tube thereby has been made as portable and as easy to use as an X-ray tube.

Electrons are released by the heated tungsten filament, or cathode, at relatively low velocity—a matter of a mile or two per second. Between the cathode and the anode—the "window" and the copper tube which serves as a shield—there is impressed upwards to 350.000 volts of direct current. This causes the electrons given off by the filament to



THE CATHODE RAY TUBE

THE HIGH POWER VACUUM TUBE AS IT APPEARS INSTALLED IN THE LABORATORY.



BALL OF PURPLISH HAZE

SHOWING THE IONIZATION OF THE AIR CAUSED BY THE ELECTRONS THAT PASS THROUGH THE NICKEL WINDOW.

speed up to an average velocity of 150,000 miles per second or more, depending upon the voltage, within the short space of about one inch between the cathode and the copper tube shield. Having attained this high velocity, the electrons coast the rest of the way through the highly evacuated tube and pass through the anode or window and into the atmosphere with but slight diminution in velocity.

The nickel window is soldered to a disk of invar, an alloy which expands the same amount as does glass when heated. The invar disk, in turn, is fused to the glass tube, thereby making the seal air tight. The thin piece of nickel itself could not withstand the atmospheric pressure of 100 pounds—the difference between the outside air and the almost perfect vacuum within the tube—so it is reinforced with a honeycomb structure of molybdenum metal, a design that affords a maximum of strength with a minimum of cross-section area.

If the tube is operated in a darkened room, a hum is heard and the window of the tube is seen to be surrounded by a ball of purplish haze, about two feet in diameter with 350,000 volts and more or less depending upon the voltage. This glow, which shows the penetration of the cathode rays in air, results from the air being ionized or broken up by the rays or electrons. The penetration of the rays depends not only upon the voltage

but upon the density of the substance they strike, so that with most solid substances the penetration is slight, and with dense metals almost negligible.

One of the most startling experiments performed with the new tube has been the production of a yellow compound when the rays are passed through acetylene gas. This compound, similar to that produced in very small amounts by radium treatment of the colorless gas, can be produced in relatively large quantities with the cathode ray tube either as a light, fluffy powder or as a varnish-like film on substances within the gas chamber, depending upon the electrical conditions. The compound has been found to be insoluble in all the many chemicals so far tried. It seems, therefore, that a use may be found for it as a protective coating for metals, to which it adheres tightly. Other substances, such as castor oil, can also be solidified by exposure to the rays.

In ascertaining the effect of the rays on living tissues, small circular areas of the ear of a gray rabbit were subjected to short exposures to the rays. Exposure of a tenth of a second caused a temporary loss of hair over that area. When the exposure on another area was increased to one second a scab was formed. When this fell away it took the hair with it, and weeks later the area became covered with a profuse growth of longer, snow-white hair. Exposure for a minute resulted in the formation of a scab on each side of the ear. A hole was left in the ear when the scabs fell away, and the edge later became fringed with white hair. In other experiments, bacteria and flies were killed almost instantly by the rays.

A crystal of calcite, a colorless and transparent mineral, glows with a bright orange light if subjected to the rays, and the glow of cold light continues for hours. The glow comes from an area very near the surface of the crystal since the rays penetrate but little into the substance. Immediately after the crystal has been rayed, numerous bluish-white sparks or scintillations can be noticed beneath the surface of the crystal; these are electrical explosions, the result of the bombardment of the atoms in the crystal by the high-speed electrons.

Granite, a mixture of several minerals, glows with several brilliant colors, some of the colors fading away immediately and others remaining for some time. Numerous other substances can be made to change in color, some permanently and others for a short time.

The commercial possibilities of the tube, still a laboratory development, are unknown but it is expected that the tube will be invaluable in scientific investigations regarding electronic phenomena.

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